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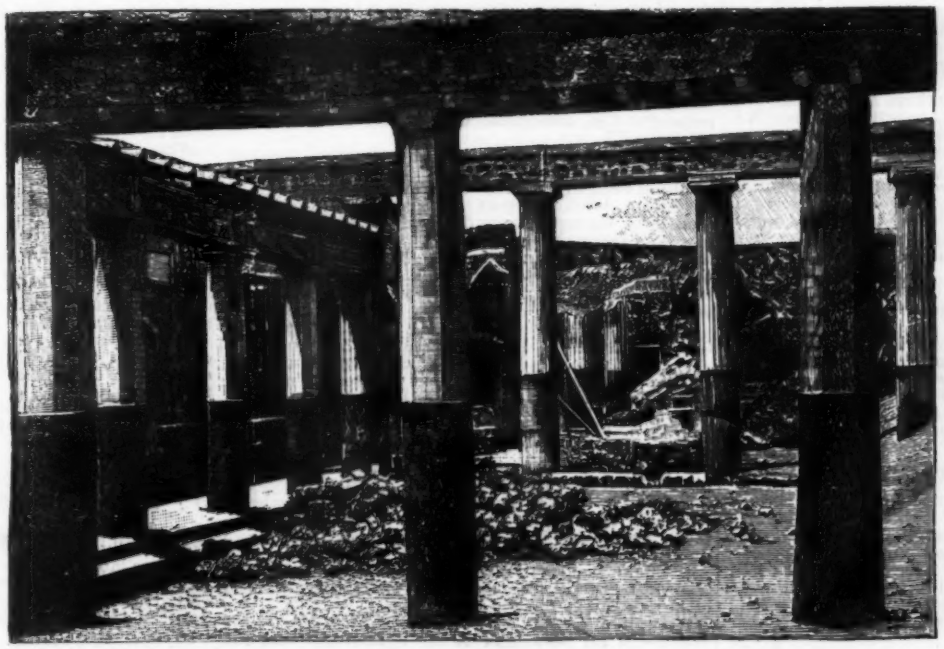
NEW DISCOVERIES AT POMPEII.

It is now about a hundred and fifty years ago that the first stroke of the archæologist's pick was given in the ruins of Pompeii. Since then about a thousand volumes, pamphlets or articles have been published upon the destroyed city; and yet the words of Mr. Gaston Boissier are ever true: "Although much has been said about Pompeii, much remains to be said about it." After some months of fruitless researches, there has been brought to light, in fact, a new house, the architecture of which is sensibly different from that of the others. The parts restored are, up to the present, the *peristylium*, the *atrium*, the lateral chambers, and, behind the *peristylium*, the bath, the kitchen, and the service chambers. The main entrance is still unknown. It is supposed to be some yards distant, in Mercury Street. We give a view of the *peristylium* with its half round and half octagonal columns, and a view on page 13961 of a wooden door that separates the *atrium* from the *peristylium*. This door had to be strengthened with plaster in order to preserve it. The mosaic pavement of this new house is very beautiful. The rooms are ornamented with frescoes, which are, as a general thing, in a bad state, save one representing Hercules, and some pygmy scenes. It is, moreover, only by its architecture that this new house is distinguished from all the others that have been discovered up to the present, and they are numerous. From this point of view, we must describe it. It must be recalled that Pompeii presents the interesting peculiarity that all the styles, all the reminiscences of Egypt, Greece, and the East figure in its structures and artistic decoration. Pompeii, a city without industries and commerce, was a true place of retreat whither the rich merchants of Italy, whom a sojourn in Rome disquieted, came from time to time to rest themselves during the course of their business, or for good after making a fortune. These brought hither a fancy bred of all the recollections of their somewhat cosmopolitan existence, and this explains the often very original character of what they have left us.



PERISTYLIUM OF A HOUSE RECENTLY DISCOVERED AT POMPEII.

Finally, what has not happened for a long time, there has likewise been discovered, in another part of Pompeii, two cadavers, one of a man and the other of a woman, side by side. We give a figure of them herewith. Were it not for a certain contraction of the man's limbs, these two bodies, we are told, would present the aspect of the calmest sleep. The relative state of preservation in which they are found is explained by the enormous envelope of ashes with which they have been covered for centuries, and which has isolated them from the external air. The bodies appear after a manner as if petrified. It is thus that many were found in the time of the first researches, all having attitudes that indicated that the catastrophe had surprised them in the full activity of their ordinary existence. These bodies will be placed in a special museum.—*L'Illustration.*

THE DEVELOPMENT OF CAPITAL AT ROME.

By LAWRENCE ALEXANDER HEMPHILL, Ph.M.,
Wooster, O.

THEORETICAL political economy is a comparatively new science. The reasons for this, in general, may be said to depend upon the necessary conditions for any considerable development of social theory. In the first place, the phenomena must have taken place on a sufficiently extended scale to supply adequate matter for observation and afford satisfactory basis for generalization; and, secondly, the observer must have been trained for his task. There must have been such a previous cultivation of the less complex science as will have both furnished the necessary data for elaborating theory and prepared the proper methods of investigation. The sociologist must have at his command a general knowledge of the principles of many sciences. Since the sciences in ancient times were in such a very incomplete and rudimentary state, a really scientific sociology was then impossible. It required a much later time for its development. Though the Romans had no authors who wrote directly on the subject of economics, still it is not impossible to arrive at some conclusions in regard to the conditions of the production and distribution of wealth among them.

Sources of Information.

1. Roman writers, historical, biographical, legal, philosophical, who either directly or indirectly speak of economic facts. Occasionally, yet rarely, we find in these some hints of economic theory.

2. Writers referring to economic facts among the Greeks and other nations contemporary with the Romans, which nations we may believe to have been on a similar plane of development.

3. Modern investigations of economic conditions and social customs existing in more recent times among nations and tribes that have not been influenced very greatly by modern civilization.

4. Reports of archæologists and discoverers.

5. Philology.

Definitions.—Political economy is the science of the production, distribution and consumption of wealth. A complete view of the science involves a study not only of wealth, but also a study of man in his nature, motives and customs.

Capital is that portion of production that is reserved from present consumption to supply future wants and further increase production. It is less in extent than the sum total of wealth.

Economic Conditions Existing at the Founding of Rome, and Previously.—We have no historic information as to the first migration to Italy of its earliest inhabitants. It is, however, probable that they entered Italy from the north. It is at present the generally accepted theory of the history of the Aryan race that they had their original home in the valley of the Volga, that various stocks migrated from thence, the Greeks and Italians remaining together for a time, and finally that the Italians advanced into Italy, being broken up into numerous tribes. Even if we accept

BODIES RECENTLY DISCOVERED AT POMPEII.

the theory of the Trojan origin of Rome, still the main stock of the early Romans was Italian.

Before the original Aryan nations had left their home in southern Russia, they had advanced beyond the hunting and fishing stage of civilization. They were in the pastoral stage and had not yet reached the agricultural stage. The proof of this is philological.[1] The words for the domestic animals, as ox, sheep, horse, goose, duck, correspond in Latin, Greek and Sanskit. Those for flock, swine, bull and dog, correspond in Latin and Sanskrit. A comparison of language also shows that they had houses or huts, boats and wagons. They understood the art of sewing, the use of fire for preparing food and of salt for seasoning it. They had a knowledge of the metals copper, silver and gold. A comparison of languages also leads to the conclusion that they were not acquainted with agriculture.

The combined Greeks and Italians before their separation, besides their pastoral life, were engaged in the cultivation of grain and of the vine. The proof of this is also philological. The Latin words for field, garden, mattock, plow, barley, millet, turnip, mallow and wine have corresponding Greek nouns. There are also common words found indicating the operations of plowing, cultivating grain, treading it out with cattle and grinding it.

At the founding of Rome there existed the rudiments of manufacturing and commerce.

1. The Romans were warriors and must make weapons and armor.

2. The legend of Tarpeia[2] shows that their near neighbors were acquainted with gold ornaments, and we cannot suppose that the Romans were altogether without that knowledge.

3. Numa, second king of Rome, established eight guilds of craftsmen, flute blowers, goldsmiths, coppersmiths, carpenters, fullers, dyers, potters and shoemakers.[3]

4. Numa instituted games, markets, and all kinds and occasions for the people to meet together.[4] Since Numa comes so near the founding of the city, and since tradition ascribes to him these institutions that indicate some considerable advance in manufactures, we can be certain that the rudiments of manufacturing existed at the very founding of Rome.

5. We might infer this also indirectly from the general history of civilization. As seen before, the Italians had learned agriculture before they migrated to Italy, which was long before the founding of Rome. It is quite likely that there was sufficient time for them to make considerable progress in manufacturing.

6. In the excavations in the Alban Hills[5] there have been discovered many specimens of Etruscan and Italo-Greek pottery. These specimens are of such a character as to show that pottery was both imported and manufactured at a date as early as the founding of Rome. In this connection we may quote the verse of Tibullus:

"*Fictilia antiquus primum sibi fecit agrestis pocula.*"

The Romans had not advanced beyond the bronze age at the founding of Rome.

1. There is no mention of a guild of iron workers among the guilds established by Numa.

2. In the fossil cemetery at Alba Longa, buried by volcanic action, no trace of iron has been found, though there are numerous bronze vessels.

3. There is no iron found in the archaic tombs within the walls of Servius Tullius.[6]

4. Lucretius[7] says:

"*Et prius aeris erat quam ferri cognitus usus.*"

(and the use of bronze was known before that of iron).

5. Early religious rites show such an abhorrence of iron that we may infer that iron was regarded as a profane innovation; *e. g.*, the sacred plow with which the limits of a new city were traced out, and the knife or razor of the *flamen Dialis*, must be of bronze.

6. Macrobius, who wrote in the fifth century of our era, says that from a very remote period brass instruments alone could be used for religious purposes, and that whenever iron chanced to touch a temple or shrine, sacrifices must be made to expiate the profanation.

7. The earliest of Roman bridges, the *Sublician*, built by Ancus Martius 114 years after the founding of the city, was built entirely without iron.[8]

It is probable, however, that iron was used before the close of the period of the kings.

The great mass of the people of Rome near the time of the founding were engaged in farming.[9] In the earliest days the Romans depended more on the raising of flocks and herds than upon the cultivation of the soil. 1. The traditions of the Romans show this to have been the case.[10] 2. The earliest designation of wealth and money was "*pecunia*." 3. The separate possessions of children and of slaves were known as "*peculium*."

Most of the early Romans were engaged also in the cultivation of the soil. The farms were small.[11] The method of farming and the farming machinery were extremely rude. The farms were tilled mainly by the owners and their families. The cultivated land was owned, at least by the time of Servius Tullius, by the cultivators, and the pasture land was owned by the state. There was thus substantial equality of fortune among the citizens.

It is not unlikely that many of the people were engaged in the hand crafts. Mamers, god of war, Mamurcus, armorer-god, and Volcanus, fire-god, were early celebrated. The arts of agriculture, forging of weapons, and war went hand in hand. There is no evidence that, in early times, the hand crafts were despised as they were at a later date. The spinning and weaving were carried on by the women of each household,[1] even by women of high rank, as Tanaquil[2] and Lucretia.[3] The houses were rude[4] and there was little knowledge of architecture; even as late as the time of Tarquinius Superbus the Romans had not attained much skill in architecture, but were dependent on the Etruscans.[5] It is not likely that there was any considerable commerce in early days. Ostia was not founded till the time of Ancus Marcius. There was no considerable development of capital. There is no evidence that there were economic difficulties between different classes of citizens in this early age.

We may now turn aside for a short consideration of ancient society, the family, gens and nation. Ancient society consisted of collections of families and gentes as units, not of collections of individuals as does modern society. The family was larger in extent than the modern family. There was no legal age of majority and children and children's children were under the father's power. There were also numerous clients, dependents and slaves. The property was owned in common. Although there was a sense in which the father had full control, yet there must have been considerable restriction on his freedom.[6] The right of the individual was subordinate to that of the family and the right of the family subordinate to that of the gens or village community. We may notice some of the respects in which this restriction appeared.

1. The pater could make no will except by permission of the *comitia calata* or assembled burgesses.

2. Tendency to keep the property together at the death of the father.

3. The complete dependence of women and their inability to hold or control property.

4. The extreme difficulties in the way of transfer of property; *e. g.*, mancipation by the formula, "*per aes et libram.*"[7]

5. The continual restriction of individual freedom in the management of property. The fixity of custom, reaching even to methods of production.[8]

With the development of society communal property tended to change into individual property, the pasture land being the last form of property to undergo this change. For a long time in early Rome large numbers of the people, the clients and plebs, could not legally hold property. This affected industry in many ways.

We may now notice briefly some of the changes that took place in the Roman government.[9]

1. In early times there was a king over a union of gentes. He usually protected the weaker members of the gentes against the stronger. There was an aristocracy of the leading members of the gentes. There were clients and plebs.

2. In the process of time, the king is dethroned and the aristocracy obtains the rule. The government is nominally a republic.

3. The ties which bound the clients in a species of servitude to the full citizens became loosened. The plebs begin to struggle for equal political rights and finally attain them.

4. There then takes place an economic struggle that leads at last to the overthrow of the republic and the establishment of the empire.

Economics of the Republic Previous to the Punic Wars.—In all periods of Rome agriculture was the main element of national economy. In the early days of the republic the money lender appeared to be the inveterate foe of the small farmer. The warfare against the Tarquins compelled the farmer to neglect his farm and to borrow from the money lender (usually a rich patrician). The laws of debt were severe, giving the person of the debtor over to the creditor. When almost the entire population of small farmers were oppressed with debt, they seceded to the Mons Sacer and the Aventine. The discord was settled by the freeing of all slaves for debt and by a cancellation of debts.[10] The fact that there were those who could lend shows that there was a considerable development of capital even at this time, though, when we consider the low state of civilization and the few wants of the people, we see that it does not at all compare with the growth of capital that afterward took place.

At this period another element of economics to be considered was war. How often do we read of raids and forays, of devastations of the fields, of the sack and plunder of towns and cities. Sometimes the proceeds of the sale of the spoil came to the treasury of the state, but we frequently find that it came to the share of the soldiers. A campaign might thus prove more profitable than peaceful industry. A part of the lands of the vanquished was frequently taken from them and bestowed upon Roman colonists or else kept nominally as state land and usurped by the patricians. Frequently the vanquished population of a captured town would be sold as slaves. This produced an injurious effect on the conquerors. Slave labor gradually displaced free labor during this period. The farms were enlarged in size, and farming was carried on by overseers and gangs of slaves. Public land became inclosed and usurped by the wealthy. The small farmers disappeared. There was economic distress causing civil discord. This was allayed by founding colonies in conquered territory, by further wars and conquests and distribution of booty, by a law that owners of farms should keep a number of free laborers equal to the number of their slaves, and by agrarian laws. During this period there is a great complaint of debt and excessive interest. The early severe laws of debt are gradually relaxed. Usury laws are enacted. In B. C. 352[11] the state assumes the payment of some debts and adjusts others in the interests of the debtors.

In manufacturing industries, numerous new crafts were introduced and there came to be considerable division of labor, *e. g.*, the numerous varieties of tailors and shoemakers,[1] of gold and silver smiths, of jewelers and makers of statues of gods. These industries were carried on mainly by the employment of slave labor,[2] or by the labor of freedmen. Hence these occupations came to be despised by the free born Romans. Retail dealing, traffic and commerce increased. This was mainly carried on by freedmen, by means of capital furnished by their former masters. The profits of all kinds of business tended so largely into the coffers of the wealthier citizens that there never arose in Rome a middle class of independent tradesmen and merchants. The great capitalists were at the same time large landholders. The manufacture of salt was a government monopoly.

The first distinct information that we have of the formation of corporations of capitalists occurs at the time of the second Punic war.[3] At this time, B.C. 215, there appeared three companies of nineteen men, which took contracts for furnishing supplies to Publius and Cnæus Scipia in Spain. They were to furnish the supplies to the state on credit and were to be repaid when there would be money in the public treasury. We notice also that the state insured the ships on which the supplies were transported against loss by storms and by hostile attacks. About the time of the second Punic war it was considered unbecoming that a senator should engage in commerce, and a law was passed (B. C. 218) forbidding any senator or son of a senator to have a ship of over 300 amphora.[4]

Economics Toward the End of the Republic.—Rome extended her power over all her rivals and made the world tributary. Her period of growth was a period of foreign war. During the period of conquest, economic evils did not come prominently to view. They existed, it is true, but their injury fell mainly on the vanquished peoples. The conquerors were fairly prosperous. As we mentioned before, legal restrictions on the free use of capital, protecting the poorer classes from its oppression, together with further conquests, adding material wealth to all classes of the Romans and furnishing new avenues for the employment of capital, allayed the social discontent that arose at numerous times during the earlier centuries of the republic. During the later period of the republic, in dealing with economic questions, we must consider as Romans the entire population of Italy, which, in the previous period, we considered as foreigners. When the Roman republic attained the position of mistress of the world, economic evils appeared on a more extended scale than ever before, while the resources for curing them were totally inadequate. Indeed, it seems as if the evils were incurable. We shall consider in detail some of the phases of economics as they appear.

Land.—Whatever land before had been owned by the state finally was inclosed and appropriated by private owners. Small farms entirely disappeared.[5] The owners of large estates rarely had them cultivated by tenants. The larger estates consisted of about 240 *jugera*.[6] Those who wished to invest more capital in farming did not enlarge this estate, but acquired several estates.[7] Each estate was managed by a steward (usually a slave or freedman) and a gang of slaves. Few free laborers were employed except in busy seasons and in unhealthy districts. Hired laborers usually received part of the produce instead of wages. The grape and olive harvests were let to contractors. There was some considerable development of machinery for producing oil and wine. For the capital invested, cattle raising was the most profitable branch of farming; then sheep raising, vineyards, vegetable gardens and olive orchards—grain raising being least profitable. Many Roman capitalists purchased or leased estates outside of Italy to carry on agriculture and cattle raising.

Manufacturing.—Industrial art remained comparatively undeveloped. It is probable that a great deal of the spinning and weaving was done by each family for itself. Yet there must have been considerable other manufacture of cloth.[8] Other branches of industry attained some considerable development. Cato, *Re Rustica*, advises the Campanian landowner to purchase slaves' clothing and shoes, plows, vats and locks at Rome. Many manufactured articles, however, were imported from Egypt and Asia. On the whole it cannot be said that manufacturing industries advanced much beyond the point mentioned at the close of the preceding period.[9]

Money Lending and Banking attained a great development. *Feneratores* and *argentarii* were found throughout all the provinces. Their importance is seen in Cicero's statement[10] that their losses in Asia by the Mithradatic war weakened credit at Rome. As early as the time of Cato, the banker received and made payments for his customers, invested and borrowed money for them and carried on their money dealings at home and abroad. They also engaged in numerous other branches of business. Their business was regarded by many of the best men at Rome as disreputable and they themselves as a class were universally hated. Usury laws were not very successful in restraining the evils of excessive interest.

Speculation and Contracting.—We find speculators and contractors for almost every branch of business. Crassus made a considerable portion of his fortune by buying up houses adjacent to burning buildings and then putting out the fire by means of his numerous slaves. The state let out the collection of all its more complicated revenues and all contracts for furnishing supplies and erecting buildings to capitalists or associations of capitalists. Contracts between individuals were

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[1] Schrader's *Prehistoric Antiquities*. Mommsen, *Hist. of Rome*, Vol. I, Ch. II.

[2] Livy, Book I, 11.

[3] Pliny, *N. H.*, XXXIV, 1, sec. 1; XXXV, 46, sec. 159; Plut., *Numa*, 17.

[4] Cic., *De Rep.* II, 14.

[5] Lanciani, *Ancient Rome in the Light of Recent Excavations*.

[6] Lanciani.

[7] *De Rerum Natura*.

[8] Dionysius, V, 24; Varro, V, 83; Ovid, V, 622; and Pliny, N. H. XXXVI, 28.

[9] Cato, *R. R.* Pref.

[10] Livy, Bk. I, 4; Cic., *De Rep.* II, 9.

[11] Varro, R. R. I. 10; "*Bina jugera a Romulo primum divisa viritim.*" Pliny, N. H. XVIII, 3; Cic., *De Rep.* II, 14; Livy in numerous places mentions that two jugers were given to each colonist in planting a colony.

[1] Col. *De. R. R.* XII, Pref.

[2] Pliny, *Nat. Hist.* VIII, 48.

[3] Livy, Bk. I, 57.

[4] Pliny, *Nat. Hist.* XVI, 15.

[5] Livy, Bk. I, 56.

[6] Marshall, *Principles of Economics*, pp. 14-16.

[7] Morey, *Roman Law*; Maine, *Ancient Law*.

[8] Marshall, *Principles of Economics*.

[9] De Coulanges, *The Ancient City*.

[10] Dionysius, VI, 83; Duruy, *Hist. of Rome*, Vol. II, p. 295.

[11] Livy, VII, 21.

[1] Plautus, *Aul.* Act. III, sec. 5.

[2] Mommsen, *Hist. of Rome*, Vol. I.

[3] Livy, Book xxiii, 49.

[4] Livy, Book xxi., 63.

[5] By small farms we mean those which, with the method of cultivation then employed, could have been tilled by the owner and his family; *i. e.*, farms of not over 30 *jugera*.

[6] Cato, *R. R.*

[7] Mommsen, *Hist. of Rome*, vol. ii., ch. xii.

[8] The importance of the industry of fulling cloth is attested by the frequent notice of fullers in comedy; by the statement of the profitable nature of fullers' pits, *Cato* 21, 1; and by the illustrations of fullers' workshops as seen in Pompeian pictures.

[9] Mommsen, vols. iii. and iv.

[10] Cic., *Pro Manil. lege* 7.

made for erecting buildings, for gathering the harvest, for partitioning an inheritance or settling up a bankrupt estate, for giving spectacles and gladiatorial games.

Commerce was extensive, owing to the comparatively small amount of manufacturing, to the decline in agriculture, and to the growth of luxury. All the provinces poured their treasures into Rome. Successful voyages brought great wealth, but the risks from piracy were great. This was a considerable factor in regulating the prices of provisions.* The actual work of commerce as of all these other branches of business was carried on mainly by slaves. Trusty slaves or freedmen managed the ships and warehouses, mines and factories, branch banks and counting rooms.

Corporations, Associations and Partnerships became numerous. They became really a kind of insurance. The state contracts were let to partnerships of capitalists, for the sake of greater security. Transmarine transactions, being especially hazardous, were mostly engaged in by partnerships. Cato advised the capitalist not to fit out a single ship with his money, but to enter into partnership with forty-nine other capitalists, so as to send out fifty ships, and to take an interest in each to the extent of a fiftieth share.† We have some indications also of the coalition of rival associations to establish monopolistic prices.‡

Distribution of Wealth.—Wealth had increased very greatly. Luxury abounded. The whole world was laid under contribution to supply the wants of the Romans. The wealth was, however, very unequally distributed. Cicero quotes the tribune Philippus as making the public statement that less than two thousand men owned the mass of the property of Rome.§ Cicero does not dispute the statement, though he finds fault with the tribune for complaining of that state of affairs. The middle class, *i. e.*, people owning a moderate amount of property, had almost completely disappeared. There was, besides the slaves, an exceedingly numerous class of free citizens, destitute of property. Some of these were in the armies, but probably the largest number formed the lazy, idle mob of the proletariat of the city.

The evil of the disappearance of the Italian small farmer was recognized by many of the wisest leaders of the Romans, and efforts were made by reformers to check it. One of the most important of these measures was the agrarian legislation of the Gracchi. By the provisions of the agrarian law of Tiberius Gracchus no one could occupy more than 500 *jugera* of the *ager publicus*, though a father could reserve in addition 250 *jugera* for each of his sons.* All the state land in excess of this, previously occupied by the wealthy, was distributed among the landless in farms of 30 *jugera*, to be held as inalienable heritable leaseholds, on payment of a small tax or rent to the state.† A comparison of the census of B. C. 125 with that of 131 shows that this law actually increased the number of burgesses, *i. e.*, landholders, by nearly one-fourth.‡ This law, however, fell into disuse, as did also the laws of Caius Gracchus; and the causes that were producing the disappearance of the middle classes went on steadily until, as we have seen, the wealth was concentrated in the hands of the few. Pliny, looking back upon the closing years of the republic as well as upon the events of his own time, declared that broad estates had ruined Rome.§

Let us now consider some of the ways in which this growth of capital and wealth affected social conditions. The possession of great wealth fostered the desire to possess more. Many methods of acquiring wealth that had been regarded as dishonorable began to be eagerly pursued. Bribery at the elections, jobbery in public contracts, venality in the courts, and corruption in high places became almost universal. Wealth purchased official position, which in turn gave opportunities for misusing public trust for private gain. Especially was this true in the case of the provincial governors and farmers of the public revenues. The condition of the inhabitants of the provinces was deplorable. They were misused and oppressed, robbed and tortured, nor had they redress from the venal courts. It was only occasionally that a notorious extortioner was brought to justice and compelled to make reparation. The revolt of Fregellæ (B. C. 125)

WOODEN DOOR BETWEEN THE ATRIUM AND PERISTYLIUM.

Let us now consider some of the conditions that led to the *disappearance of the middle class* and the concentration of the wealth into the hands of the few.

1. The losses of life in the constant wars fell most largely on the class of small farmers, for they formed the bulk of the armies.

2. The demoralization of camp life. Men came to look on military service as a profession. The state furnishing food and clothing, ‖ and numerous chances of booty being likely to occur, a careless prodigality on the part of the soldier replaced the prudent and sparing habits of the husbandman. When disbanded the soldier refused to return to daily labor on the farm and prepared to swell the crowd of the proletariat of the city.

3. There never had arisen a very considerable number of the middle class among merchants and manufacturers.

4. The rich land owners frequently forcibly dispossessed the neighboring small farmers of their possessions and there was no redress from the venal courts.

5. Most of the conquered peoples of Italy were forbidden the right of traffic (*commercium*). The Roman colonists throughout Italy thus had such a great advantage, in the way of opportunity for gain, over the Italians that the latter could never acquire property by traffic.

6. The policy of the government in importing vast quantities of grain to Italy, to be sold often at less than cost and rendering it impossible for the Italian small farmer to compete.

This grain was frequently received as tribute and distributed to the poor of the city.

7. The greater economy of the management of large farms, rendering it impossible for the smaller to compete with the larger capitals.

8. Slavery.

and the social war (B. C. 90) give evidence of the oppression of the people of Italy by the ruling class at Rome.

Probably one of the most marked features of the social condition was the institution of slavery. Capital exerted itself here in its most tyrannical form. Slaves and cattle were placed on the same level. They were fed as long as they could work, because it would not have been good economy to let them starve; and they were sold when they could no longer work, because it would not be good economy to retain them longer. They were kept at incessant work. They had ever before them the fear of the prison and the yoke, the lash and the cross. The system was probably the most cruel that ever existed. The great slave insurrections in Sicily (B. C. 134–132) and in Italy under Spartacus (B. C. 74–72), the numerous smaller risings of slaves at various times, and the fearful punishments inflicted, show the utterly wretched condition of this class of the people. The baneful effects of slavery affected free labor. Handicrafts and manual labor of almost all kinds came to be despised by even the most liberal-minded of the citizens. The employment of slaves to a large extent, being more profitable and economical for the capitalist, closed many avenues to the employment of free labor. "Driven away from their inheritance by usury or the avidity of their rich neighbors, thrown out of work by the competition of slaves or else discontented with the frugal life of their fathers, by reason of the habits of idleness and debauchery contracted in camps, the poor turned their steps toward Rome."‖

"The numerous holidays, the triumphs, the days of supplication for victories, the frequent distributions made by the ædiles, by patrons, by candidates, and the prejudice which branded the small trader with infamy, all tended to produce idleness." "To listen to the orations in the forum, to frequent the games, to hang about some great man's door, and accompany him when he went out; also to sell one's vote, one's testimony in court, in case of need one's strength—these were the day's employment."* In the earlier days of the republic the armies were filled by the landholders, but from the time of Marius, they were recruited from the city rabble. This proletariat produced soldiers attached to a man to a Marius or a Sulla, to a Pompey or a Cæsar, to an Octavius or an Antony, and not soldiers loyal to the republic. The wealthy extended their power into politics, where if not actually obtaining the offices of power and influence for themselves, they obtained them for their creatures. They influenced legislation and the administration of government in their own interests. The oppression, discontent, jealousy and strife of all classes of the people increased. All attempts at real reform, moderate as well as revolutionary, were thwarted by the ruling oligarchy. The power of wealth increased. Single individuals and combinations of a few individuals at times became more powerful than the state. Discord and civil war ensued. A Cæsar seized the state and the republic was no more.—*The Post-Graduate.*

FLORENTINE PIETRA DURA OR MOSAIC WORK.

HER Majesty's Consul-General at Florence says that the proper technical term for the so-called Florentine mosaic work is *commesso*. They are composed of delicate slices of stones, carefully cut into shape, arranged and joined together (*commessi*) with a fine cement, and then fitted into a thin slab of marble. The pictures are produced by the natural tints of the stones, the selection of which requires great taste and skill. Works in *commesso* are executed in the following manner:

After the design has been prepared, the thin slices of stone selected for the various parts are distributed among a certain number of workmen, each of whom completes the portion of the design intrusted to him, the whole subject being subsequently united. The stones, after being cut into the required shapes, are carefully set together with a cement made of wax and mastic (*pece greca*), heat being used to bind them together. Slate is employed to support the work during its progress, and to line it when complete. At each stage the first lining affixed to the separate parts is ground down and a fresh one affixed, so that an even surface may always be secured. When the complete design is fitted into the marble slab prepared for its reception, the whole of the base is again ground down to a perfect plane, and is lined with a fresh backing of slate. The fitting is performed with the greatest care, the edges of the several parts being filed until the exact dimensions have been attained. The whole surface is afterward polished, so that the lines of juncture are rendered almost invisible. To bind on the lining heat is used, as also for uniting the small pieces. The operation is very carefully performed, so that no more cement than is absolutely required should remain between the parts that have been joined together.

The first operation of sawing the stones into thin slices, from 2½ to 3 millimeters in thickness, is performed by means of thin blades of iron or copper, emery powder giving the required friction. The slices are further sawn into the shapes required to form the various parts of the design by iron or copper wire attached to bows, and always with the aid of emery. The finest emery powder (*polliglia*) is used for polishing the surface of the stones, and emery is employed for grinding down the linings. For this purpose the work is placed on a fixed slab of marble or slate, iron plates of various sizes and thicknesses, according to the dimensions of the slab, and having wooden handles, being steadily worked over it by one or two men, as required. Sir Dominic Colnaghi says that it would be interesting to trace the origin of this art, and to follow its development from classic times, through Siena to the present style of work, which began to be practiced about the middle of the 16th century.

Portraits, landscapes, and architectural views were first produced, but it was soon felt that these subjects were unsuited to the materials employed. Decorative designs and imitations of fruits and flowers therefore took their place, and form the most successful subjects of modern work executed in *pietre dure*. It has been doubted whether the introduction of the art of working in mosaic into Florence, under the patronage of the grand dukes of the house of Medici, is due to Tuscan or Lombard artists, as it would appear to have flourished contemporaneously in both regions. While, however, it has died out—or nearly so—in Lombardy, it has survived in Tuscany, to become an important branch of Florentine industry. To provide stones for the works in real *pietre dure*, Europe, Asia, and the North of Africa have been laid under contribution, and the royal factory possesses a large collection of stones valued at some 20,000 lire. Among the principal stones employed are amethysts, agates, the sardonyx and chalcedony, flints, and many varieties of jasper pebbles from the Arno (which generally contain a large proportion of lime), and petrified woods. Among the rocks which are chiefly used for works of decoration are red Oriental, Egyptian, and other granites, *verde di Corsica*, labradorite, antique porphyry, green porphyry, Oriental serpentine, jade, basalt, silicious breccia, and *lapis lazuli*. Black marble from Belgium is largely used as a foundation, and slate, as has already been mentioned, is employed as a lining for works in *commesso*.

The hardness of the materials employed, requiring patient industry to work them, accounts for the costliness of works in *pietre dure*, of which 75 to 80 per cent. is attributed to labor. The commercial articles met with in the Florentine shops are chiefly composed of the softer qualities of calcareous stones, while shells are used for the white and pink tints, and coral is occasionally inserted. The workmanship, design, and effect are often excellent, but they are able to be produced at much less cost than the works executed at the royal factory, of which the following is a short notice. Although artists in mosaic had been employed by Duke Cosmo de Medici in previous years, the foundation of the royal factory of *pietre dure* in Florence may, perhaps, be considered to date from about the

* Cic., *Pro Mand. lege.* 15.

† Mommsen, *Hist. of Rome*, vol. ii.

‡ Cato, quoted by Mommsen, *Hist. of Rome*, vol. ii.

§ (Cic., *De Off.*, lib. ii, 21, "*Nam esse in civitate duo millia hominum qui rem haberent.*"

‖ At the time of Caius Gracchus.

* Appian I, 9; Livy, *Epit.* lviii.

† The tribune, M. L. Drusus, afterward gave these lands outright.

‡ Census of 131 B. C., 319,000; census of 125 B. C., 395,000; gain 76,000.

§ "*Latifundia Romam perdidere.*"

‖ Duruy, *Hist. of Rome*, vol. ii.

* Duruy.

year 1754, when some rooms in the Casino di San Marco were assigned for the residence of the masters of the art. The factory was principally founded to carry out the works of the great sepulchral chapel of the Medici in S. Lorenzo. This chapel would appear always to have been intended to receive the monuments of the princes of the house of Medici, and never, as tradition avers, to become the receptacle of the tomb of our Lord, which was to have been conveyed to Florence from the Holy Land by the Druse Emir Faccardin (Fakr-ed-Din). The slow progress of the chapel enabled the artists employed in the factory to execute other works, which were presented by the later Medici princes, on different occasions, to foreign sovereigns, thus extending the reputation of the factory.

Some of the artists appear to have tried their fortunes in foreign lands, and it is thought that a part at least of the works in *pietre dure* executed in the Taj Mahal of Agra, are of Florentine origin. In 1738 a small factory was founded at Naples, which existed until 1860, when it was suppressed; but no rival rose to compete with Florence until the establishment of the imperial works at St. Petersburg for mosaic in relief, about the year 1840. The mosaics executed in the factory of the Vatican, at Rome, are of an entirely different character from the Florentine works in *commesso*. On the overthrow of the grand ducal government in 1860, the works of the Medicean chapel were suspended until the beginning of 1883. Since this date about 135 square meters of the pavement executed in *commesso* on a large scale have been completed. The total area of flooring of the octagon, excluding the recesses, is 642 square meters. The completion of the chapel has been intrusted by ministerial decree to the royal factory. The total cost up to the present time is estimated at 16,300,000 lire, or $3,260,000.

The average annual value of the production of the factory is calculated at 52,000 lire, of which about 12,000 represent works sold in Italy and abroad on private commissions, and the remainder in part works placed in the museum of the factory, and partly repairs in mosaics, etc., existing in the royal galleries of Florence, upon which the administration of the factory now depends. The works executed are marble table tops, panels for furniture, caskets, letter weights, decorated in *commesso*, both flat and in relief, vases, cups, statuettes, columns, and other ornamental works. At the present time, says Consul-General Colnaghi, a large piece is being executed, combining all the different kinds of works—*commesso*, *intarsio*, relief, and in the round. The work consists of a large black vase, richly decorated with flowers, fruit, birds, etc., and is the first example of *commesso* work applied to a curved surface. All the work is carried on by hand; there is no machinery, though this is much needed, it is said, in the sawing department.

For about two centuries and a half the production of the Florentine mosaics had remained a monopoly of the royal factory. It was not till 1825 that there was an industrial application of the art to small articles of jewelry and ornaments. To effect this, however, the true *pietra dura* had of necessity to be put on one side, and its place taken by calcareous stones and shells, thus allowing the work to be executed at reasonable rates. Between 1863 and 1873, the period when the city was the capital of Italy, there was especially a considerable increase in the industry. Since 1873 a variety of causes—such as the removal of the capital, the cholera (which caused a temporary diminution in the number of visitors to Florence), and changes of fashion—have led to a decrease in the production. The outfit of a mosaicist is very simple. With a small table, a basin of water, a brazier, a vise, some copper and iron blades to be used as files, a bow strung with iron wire, a little emery powder, and a few stones already cut into slices, which cost only a few francs, his equipment is complete.

NEW METHOD FOR FOUNDATIONS.

THE following description is taken from the patent granted to Robert L. Harris, of New York, dated December 8, 1891:

It is well known that quicksands are often very compact and apparently solid until slightly disturbed, when they become semi-fluid, and great difficulty has been experienced in constructing foundations in and building sewers through quicksands and in excavating at the proper depth for placing foundations, water pipes, sewers, and structures of various kinds, because the water passing into the excavations loosens up the sand, and the sand is not only carried with the water, but the mass, by agitation, becomes loosened or so "alive" as to greatly impede, if not entirely obstruct and preclude, the construction of the work through such quicksand. Sand under many conditions makes an excellent foundation when confined. Quicksands, when disturbed, move freely in any direction, and thus become alive under water, even if apparently compact when quiescent.

My present invention is especially intended for use in quicksands; but it is also available in the preparatory work for the construction of foundations, tunnels, shafts, etc., in sand or other loose material, especially where such materials are beneath the water level. When a pipe is inserted through such materials down to a desired depth and water or other fluid is forced through the same, the sand or other materials will be loosened by the agitating action of the moving fluid, and I have discovered that if a second pipe is introduced through the materials to the same or nearly the same depth, a circulation can be obtained to a greater or less extent of the fluid introduced through the first pipe under pressure and passing through the sand or other loose material toward the second pipe, and so on up the second pipe, and in this manner an underground current can be produced that spreads horizontally through the sand to one or more exit pipes, so that after the materials have been more or less agitated by the current of water or fluid passing from one pipe to the other, cementing material in a sufficiently fluid condition can be passed through one pipe and will follow, generally, the looser material to the other pipe, and in this manner a layer of cement or of the cemented materials can be placed with more or less regularity at the desired depth; or by drawing the pipes successively in a vertical direction and successively repeating the operation a vertical or nearly vertical slab of greater or less uniformity can be produced by the cementing material introduced through the mass of sand or other materials while they occupy their nearly natural or ordinary position, so that by consolidating or cementing the materials in such position as to inclose a mass whose removal is intended the excavations can be proceeded with and the water will be sufficiently shut off to prevent the wash of the sand or other material into the excavations, and in cases where it is desired to do so, a foundation can be constructed in the quicksand or other material, commencing at a desired depth and forming slabs, blocks, piles, or monoliths of cement of more or less regularity and in the desired positions to form the proper supports for the superstructure.

In the construction of foundations and of sewers and in excavations for laying water pipes, etc., it is often advantageous to make use of sheet piling or cofferdam work previous to excavating in the quicksand or similar material; and I place a floor of cemented material between the sheet piling to prevent the water or quicksand from rising in the excavation from the bottom, which is usually one great source of difficulty.

In the drawings, Fig. 1 is a diagrammatic plan view, illustrating the position in which pipes may be introduced for the aforesaid objects. Fig. 2 is a diagrammatic vertical section of similar pipes, both being shown in connection with sheet piling, and Fig. 3 is a diagrammatic cross section, and Fig. 4 a diagrammatic longitudinal section, representing the improvements as applied in connection with a floor and caisson or wall. Figs. 5 and 6 are sections, in larger size, of the pipes that may be employed. Figs. 7, 8, and 9 are diagrammatic cross sections illustrating the positions in which the pipes and cement may be introduced in forming either a tunnel or a shaft, and Figs. 10 and 11 are longitudinal sections illustrative of some of the ways of using the present invention.

The pipes that I make use of may be of any suitable size, according to the character of the material in which the foundation is to be made and the positions of such pipes. I find it advantageous to make use of pipes two or three inches in diameter, of suitable length to extend to the desired place, and these pipes may have an open end and be driven or otherwise forced to place. It is convenient to introduce a second pipe, *b*, within the larger pipe, *a*, having a jet end, from which water is caused to issue to loosen the materials and allow the larger pipe to be driven or forced to its place. This manner of sinking pipes is well known. Two or more of these pipes are to be introduced into the material at the places where the cement is to be directed, and they may be either vertical or horizontal or at an inclination. I have represented them in Figs. 2, 3, and 4 as vertical. For illustration, let the pipe, 2, represent the one through which water is forced and the pipe, 3, be at a suitable distance from the pipe, 2, so that when water or fluid is forced through the pipe, 2, it may permeate the quicksand or other material and commence to rise in the pipe 3, and, as the fluid will spread around the pipe, 2, in all directions, and finally a portion of it will reach the pipe, 3, the pressure in that direction is lessened, and the flow will eventually be down the pipe, 2, and, to a considerable extent, up the pipe, 3, and in so doing the materials between the pipes, 2 and 3, will be sufficiently agitated or loosened, so that when cementing material is forced down the pipe, 2, it may spread mostly through the channel that the water or fluid had traveled until it reaches the pipe, 3, which is then preferably stopped, and the material will spread or be forced into the adjacent materials. These pipes, 2 and 3, may then be drawn up a suitable distance and the operations repeated, which is preferably after the first charge of cement has sufficiently set or hardened, and in this manner a slab of cement or cemented materials will be formed of any suitable thickness and with more or less regularity between the pipes, 2 and 3. This operation may be promoted, if desired, by the introduction of the small water pipe, B, through one of the larger pipes, 2 or 3, having a lateral jet opening or pipe for the issuing of the water, whereby the jet can be directed toward the pipe, 3, if desired, and in so doing the force of the jet will aid in the establishing of the communication between the pipes, 2 and 3.

It is advantageous to use the pipes illustrated in Figs. 5 or 6. In these, A represents the exterior or larger pipe, and B the inner pipe, and it is preferable to have a valve, D or D', near the lower end of the pipe, B, to close or open the bottom end of the pipe, A. In Fig. 5 this valve, D, is conical at its upper end, and the lower end of the pipe, A, will be open when the valve, D, is kept below it and closed when such pipe, B, and valve are drawn up. In Fig. 6 the valve, D', is smaller than the pipe, A, and closes downwardly upon the annular seat at the lower end of the pipe, A.

In use, water may be passed down the pipe, B, and loosen the sand and wash it up through the pipe, A, and this pipe, A, can be driven down from time to time. When a desired depth is reached, the valve can be closed, and the water or fluid under pressure will spread laterally until it reaches an adjacent pipe, as aforesaid. Sometimes an annular flap, E, may be connected to the pipe, B, or valve, to spread by the upward pressure into a nearly horizontal position, to lessen the flow up around the outside of the pipe, A, and to direct the fluid under pressure horizontally. This flap, being of flexible material, is folded together closely and downwardly around the pipe, D, and pushed through the pipe, A, after the latter has been put in place and some of the sand pumped out.

When suitable cement or cementing material—such as hydraulic cement or a proper quality of clay mixed with water—is to be introduced, the pipe, B, may first be withdrawn; but, generally, it is preferable to introduce such materials through this pipe, B, and to hold this pipe, B, in place and to aid in preventing the cementing material from rising in the pipe, A, under the pressure to which it is preferably subjected, a cap of suitable character may be applied to the top of the pipe, A, and around the pipe, B, as at F, such cap being secured by screws or otherwise, and rendered tight by packing.

In the construction of tiers or columns of cement in quicksand or other loose material the water may be forced down one of the pipes so as to spread in all directions, and in so doing loosen the quicksand or similar material, and this may be promoted by an alternate compression and suction of the water in such pipe or compression in one pipe and suction in another, and, if desired, the water may be pumped or forced out of such pipe to wash more or less of the sand or similar material toward the pipe at the bottom end, so that the same may be withdrawn with the water, thereby leaving a cavity in the quicksand or similar material near the lower end of the pipe, into which cementing material of a proper quality or mixed with sand to a greater or less extent may be introduced, and by the pressure caused to spread at the lower end of the pipe to whatever extent the force may send it, and by drawing this pipe upward successive additions to the cemented structure can be built up from the lowest to the highest levels, as desired. In the construction of horizontal or nearly horizontal floors the same operations are to be performed.

Let it be presumed that pipes, 4, 5, 6, and 7, are introduced to the desired depth, and water may be forced down the pipe, 4, under sufficient pressure to reach one or more of the pipes, 5, 6, 7, and 3, and, by a jet directed laterally from the lower end of the water pipe, the materials may be loosened more or less in a horizontal direction, if desired, after which the cementing material introduced at the pipe, 4, under proper pressure will spread laterally and reach one or more of the pipes, 5, 6, 7, and 3, and either of the pipes can be closed by the valve at the lower end, or otherwise, if it becomes advantageous to do so in directing the circulation or flow of the water or of the cementing material to the desired places, and the floor may be still further spread by the washing action at one or more of the pipes, 5, 6, 7, 3, the water being directed horizontally to loosen up the materials and to wash the same out to a greater or less extent, either through the same pipe through which the water was first injected or through any one of the adjacent pipes. Hence by successive operations through pipes that are applied at proper distances apart, the cementing material can be introduced horizontally or nearly so, to an indefinite extent, and will make a floor to shut off the inlet of water, quicksand, or other material before the excavations are made above the floor. This object may at times be still further promoted by sheet piling at 8 and 9, or by cofferdam or caisson work, and, if desired, the sheet piling may form a square or inclosure, there being sheet piling at 10 and 11 at the ends, and in this manner successive sections can be inclosed for the construction of a sewer or other work between the sheet piling and above the cemented floor that is put down previous to the excavation, and this mode of procedure can be adopted in making foundations and in laying water pipes, gas pipes, or drains in streets or under buildings, especially through quicksand.

In cases where tunneling is being performed the water is preferably passed into an upper horizontal or inclined pipe, so that it will descend and pass back through a lower pipe, thereby establishing a channel between the distant ends of the pipes, in order that the cement may be introduced through one pipe, and in passing down toward the other pipe the materials will be cemented together and then the pipes can be driven in further and the operations repeated until a cement wall is constructed in the materials as they lie in substantially their natural positions, and a similar proceeding can be pursued in constructing a floor for a tunnel or in applying a cement in the materials above the place where the tunnel is to be excavated, thus aiding in keeping the materials in their proper position during the excavation for the tunnel or other structure.

The walls or inclosures in the sand or other materials may be formed, as before described, any desired depth and extend to the required height, and such walls may be used alone or with the floor or horizontal layer before described, and such walls may extend above or below the floor, or both.

The improvement may also be used advantageously in the sinking of shafts through quicksands or other fine materials by solidifying, in the manner described, a shell or inclosure within which the shaft is to be sunk, or by so solidifying a mass sufficiently large to allow the excavation of the shaft through such mass. Tunnels may also be formed in the same manner.

Upon reference to Figs. 7, 8, and 9 it will be apparent that the pipes for water and for cement may form a circular range and be used as aforesaid. If the pipes are parallel, they may be forced along by hammers or hydraulic jacks, K, from time to time, as illustrated in the section Fig. 10, and additions made to their lengths, so as to introduce the cement ahead of or below the excavation. If other pipes are introduced, as shown by dotted lines, 20, Fig. 11, the whole mass of material may be solidified and the central portion excavated to the line, 21, if desired, to form a shaft or tunnel; but where the pipes are introduced at a greater or less inclination in tunnel work, as seen in Figs. 9 and 11, the water is preferably directed through one set of pipes and passes along and returns through the other set of pipes in establishing the distant channels for introducing cement. In Figs. 7 and 8 the pipes, L, are shown as receiving the downtake and the pipes, U, the uptake in opening up the channels, and then the connections can be reversed, so that the pipes, L, become the uptake and the pipes, U, the downtake. The lines and arrows illustrate the directions in which the channels are opened up, and these channels may be more fully opened up by reversing the action, as aforesaid, and cement can be introduced through the tubes, L, until it reaches the tubes, U, such tubes, U, either being open or having a suction applied to them, after which cementing materials can be also introduced into the pipes, U, and caused to spread toward the other tubes and intermingle with the previously introduced cement.

It is to be understood that these improvements are especially available where the quicksand or other material has to be excavated; but where a structure is to be erected upon loose materials, this mode of procedure can be availed of in making an inclosure, columns, or monolith in the quicksand or other materials to properly support the superstructure, and in instances where a pier, building, or other structure is found to have an insecure foundation, the foundation can be extended or enlarged into the quicksand, rubble, gravel or other loose material to any desired area or depth by proceeding, as before set forth, until the desired columns, floors, inclosing walls, or monoliths are constructed in the loose materials without removing the pier, building, or other structure, in this way preventing the further settling or giving way of the founda-

tion under the structure. The fluid that is introduced under pressure tends to spread at the bottom of the inlet pipe and displace more or less earth or other material in the direction of the least resistance. If such fluid is injected too rapidly or under too much pressure, it will tend to lift the sand or earth and escape to the surface, there usually being the least resistance upwardly. If, however, the fluid is not injected too rapidly, the tendency of gravity is to cause such liquid to percolate downward, and the result of these two forces is to spread the fluid nearly horizontally. If now the fluid or that which it displaces reaches one of the other pipes, the pressure is relieved and a route of least resistance established toward that other pipe. Hence when the uptake of that other pipe is closed and the pressure increases in the injected fluid, the tendency will be to spread farther in all directions, and especially to rise toward the surface, which usually is the direction of least resistance. Hence by availing of these conditions the cementing material can be directed almost at will through the sand or similar material.

It will be evident that this invention has a wide range of application, and that in either shafts or tunnels or other works the pipes may be driven to the greatest distance for commencing the opening up of channels and the introduction of cement, and then the pipes may be partially drawn for each subsequent operation, or else the pipes may be thrust to the place where the cement is to be first applied, and then thrust or driven to a farther or more distant point for the next operation, and so on.

I claim as my invention—

1. The method herein specified of consolidating loose materials, consisting in introducing pipes at distances apart, passing water or fluid into one or more of the pipes to loosen the material around the ends of the pipes and establish currents between one pipe and the other, and then filling the interstices and channels with cementing materials introduced through one or more of the pipes, substantially as set forth.

2. The method herein specified of producing a floor or similar structure within the quicksand or other materials, consisting in introducing pipes at distances apart and to a desired level, loosening the materials between the lower ends of the respective pipes and near the desired floor level by the action of a fluid forced into one or more of the pipes to establish a current from one pipe to another, and introducing cementing material through such pipes, substantially as set forth.

3. The method herein specified of forming inclosures

Fig. 3.

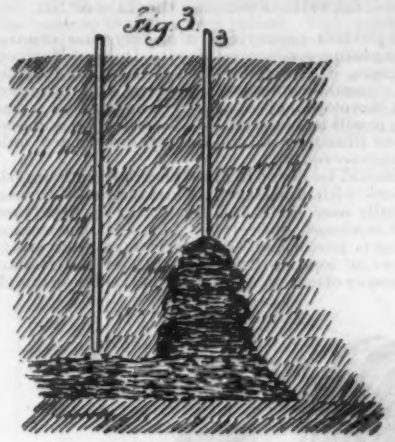


Fig. 1.

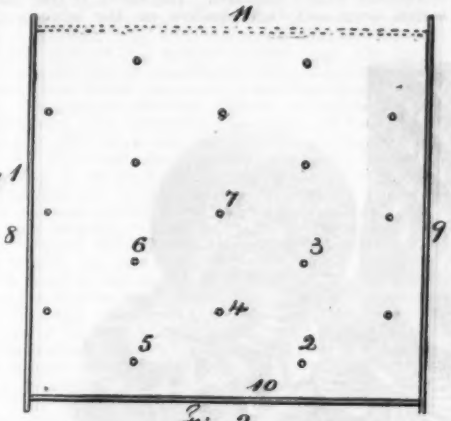


Fig. 2.

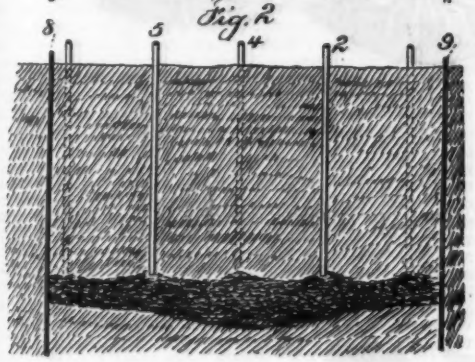


Fig. 4.

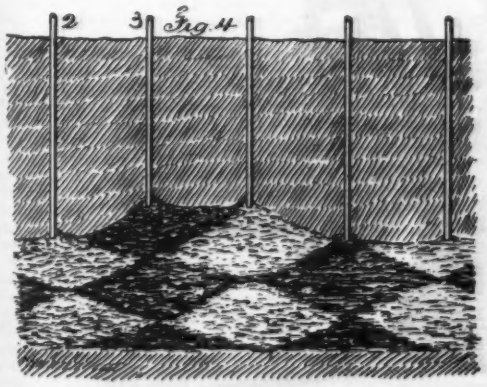


Fig. 5.

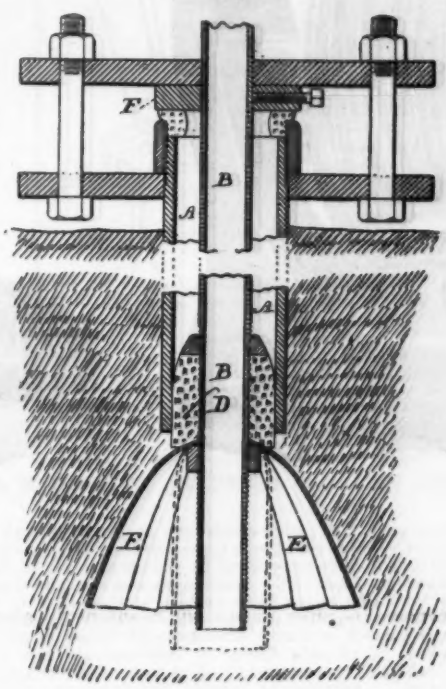


Fig. 6.

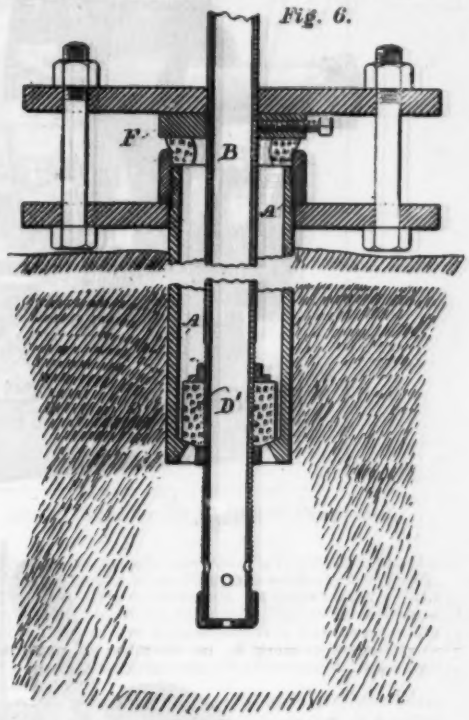


Fig. 7.

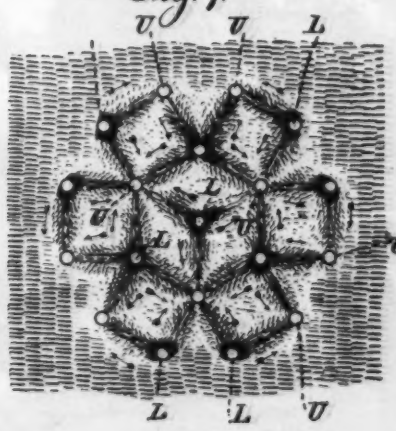


Fig. 8.

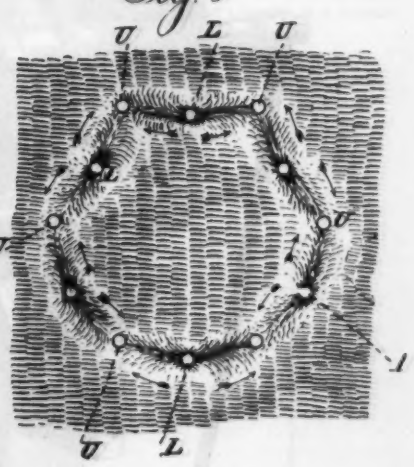


Fig. 10.

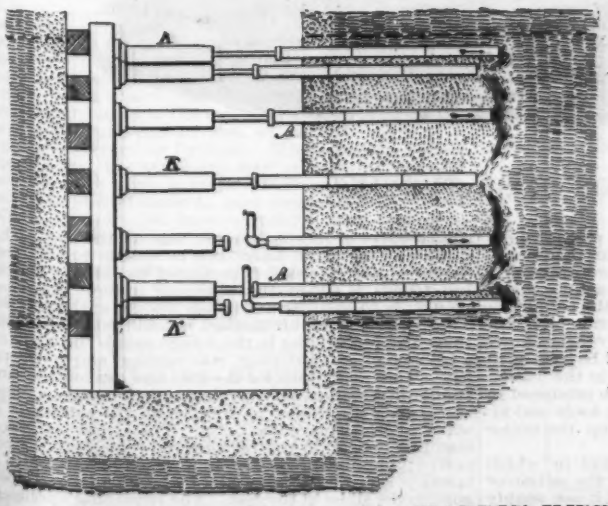


Fig. 11.

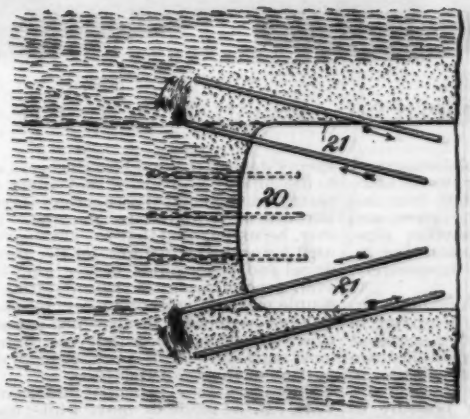
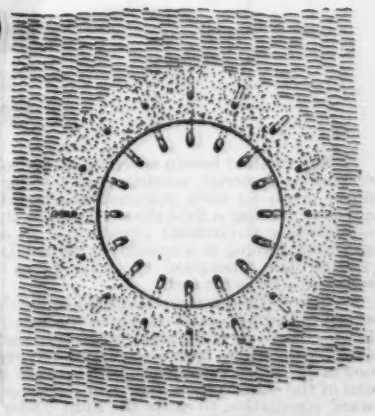


Fig. 9.



HARRIS' IMPROVEMENTS IN FOUNDATIONS.

within sand or similar loose materials, consisting in passing water or other fluid through one or more pipes and through such materials to establish currents to the other pipes, and then introducing cementing material, then moving such pipes for their ends to be in different positions and repeating the operations by introducing water to open up channels, and afterward introducing cementing material, substantially as set forth.

4. The method herein specified of inclosing quicksand or similar material to be excavated, consisting in driving down sheet piling and introducing cementing material into the sand or similar loose material through pipes passed down into the sand and between the piling to form a floor near the lower ends of the piles and previous to the excavation of such quicksand or loose material, thereby shutting off the inlet at the bottom, substantially as set forth.

LATHE FOR ROSE TURNING.

WE publish engravings of a very fine ornamental turning lathe, constructed for the Duke of Marlborough by Messrs. Holtzapffel & Co., of London. As this is a highly ingenious piece of apparatus, and represents the latest development of the ornamental or amateur's lathe, it will be interesting to describe it at some length. For our illustrations and description we are indebted to *Engineering*.

It should be borne in mind that, after having shaped his work with a fixed tool, the ornamental turner very generally uses drills and fly cutters in great variety, and it is almost entirely by them that the ornamental cutting is performed, the work remaining stationary or more or less slowly moving under the guidance of the rose or other compound chucks. These chucks are simply devices for holding the work and presenting it to the cutters, and hence they admit of far more complexity in their construction than if they were intended to rotate at a high rate of speed. It must not, however, be understood that the amateur's lathe cannot be used for ordinary turning, for the production of cylindrical and other solids of rotation; its votaries, however, generally soar in their ambition far beyond such simple matters, and find more pleasure in the execution of complicated forms which cannot be produced in this way. Hence it is that fast-running tools and almost stationary work occupy them during the major portion of their working time.

There are four principal different ways in which work can be made to move while under the action of the cutters in the lathe illustrated. First it can simply rotate. Second, the mandrel of the lathe can be made to move backward and forward endwise; this is called the pumping motion. Third, the work, while rotating, can be set to move toward and from the cutter in a horizontal plane several times in each revolution of the mandrel; this is the rose-cutting motion. Fourth, the work may be caused to move in the same way, toward and from the cutter, twice in each revolution; this is called the oval-cutting motion. Not only can all these motions be separately impressed on the work, but any two, or three, or all of them, can be brought into action at the same time. It will be easy to understand that marvelous and sometimes very beautiful effects can be obtained from some of these conditions. In Fig. 3 are shown some samples made to demonstrate the effects of different methods of presenting the work to the tool; they are not intended as finished objects, and are only specimens of cutting. The one in the center, partly hidden by the others, shows the results of the pumping motion only. The block is fixed on the nose of the mandrel, the latter being in slow rotation, and at the same time advancing and receding several times in each revolution. By means of a fly cutter the face and edge are turned, with the result shown. Another simple effect is shown in the left hand specimen; this is gained by rose-cutting alone. As the block slowly rotates it advances toward and recedes from the slide rest, the motion being in a horizontal plane through the center of the mandrel. The effect is that the cut is first deep and then shallow on the edge, while a similar effect is obtained on the boss on the face. The sample on the right hand side is similar to that just described in so far as it is produced by the rose chuck, but to this is added the pumping motion, the piece moving both endwise and across the axis of the spindle. Thus there is a double motion, in addition to the rotation. The block lying in the foreground is the result of a treble motion—pumping, rose-cutting, and oval-cutting. The oscillations for the rose and oval cutting are similar in direction, only varying in their "periods," just as at sea a ripple can be formed on the surface of a wave, and be superposed on it. The cylindrical piece standing on end in the background represents the result of pumping and rose-cutting, in combination with a spiral or screw cutting, caused by moving the tool endwise on the slides of the rest. The remaining specimen is the same as the first, and shows effects that can be

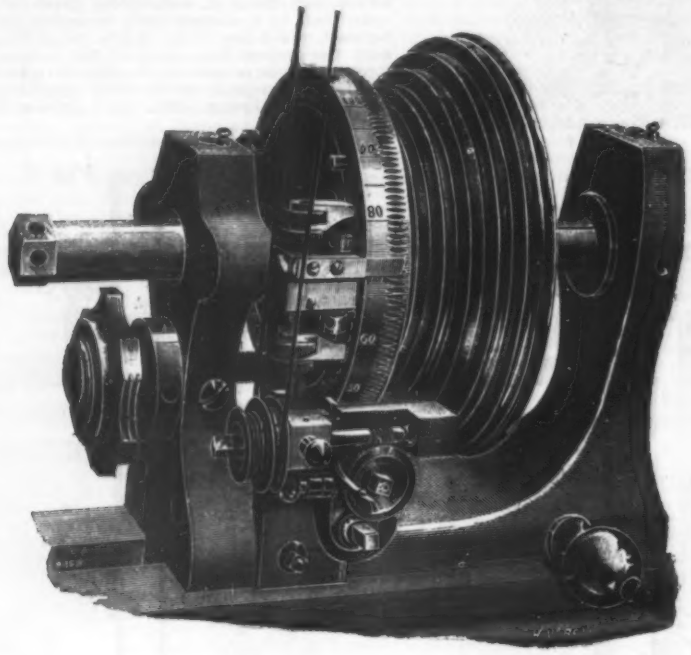


FIG. 2.

FIG. 3.

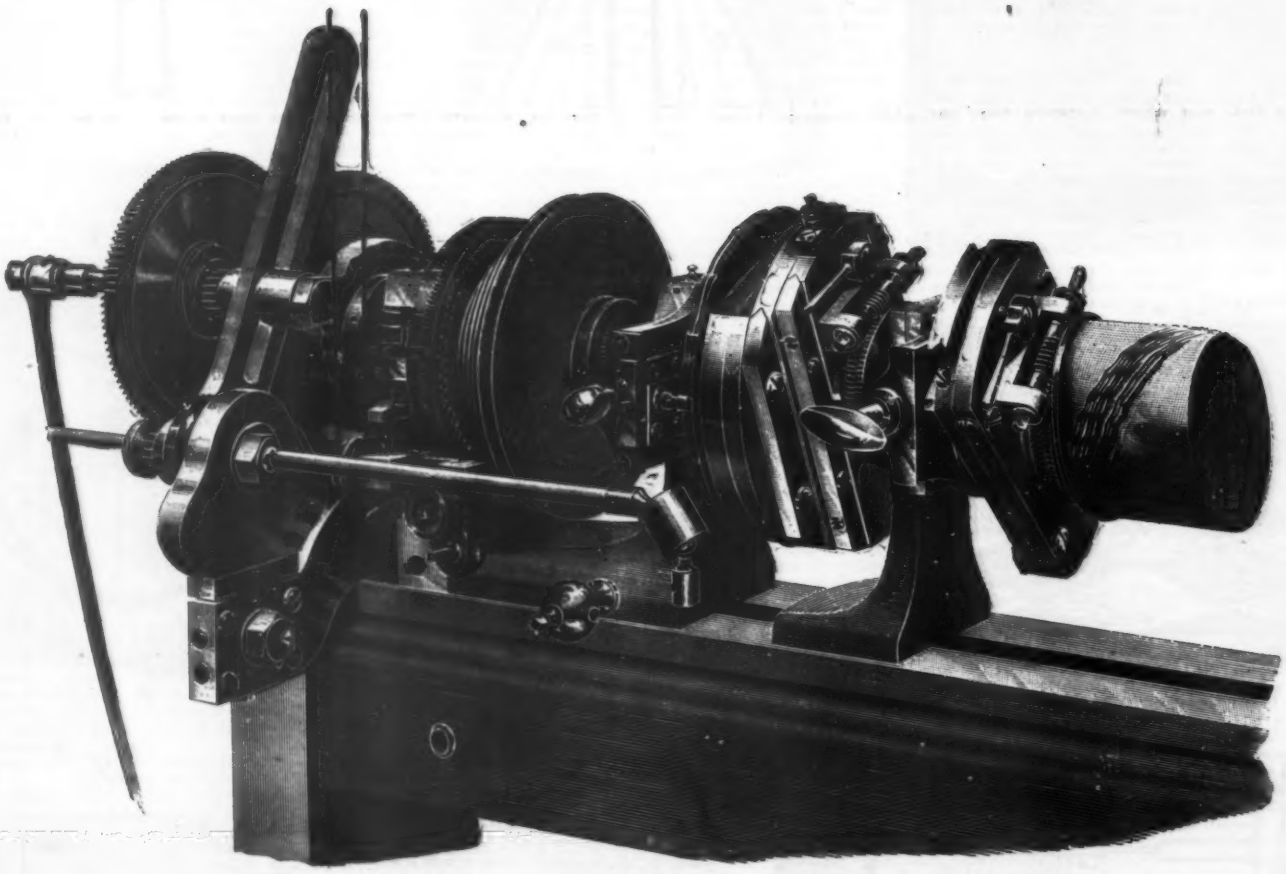


FIG. 1.

IMPROVED ORNAMENTAL LATHE FOR ROSE TURNING.

produced by recentering the work from time to time. It is executed by the rose chuck.

If we have made the different classes of work clear, it will be an easy matter to describe the mechanism by which they are executed. The lathe (Fig. 1) has a headstock (Fig. 2), with the mandrel carried in two bearings. The pumping action demands that this mandrel should have end play, and apart from this it is ordinarily made so as to allow of hollow screws being placed upon it to gear with part nuts (Fig. 2) for screw cutting. This feature is, however, quite old. When the spindle is to be fixed endwise, a sleeve is placed over it and held up to the bearing by a nut. The pumping action is produced by a wavy-edged cam (Fig. 1) fixed on the rear end of the mandrel, and running against a roller which cannot be seen in the illustration. The return motion is effected by a long bar spring pressing against the end of the mandrel. The total motion is, of course, not great. The rose chuck we have already described in detail, but we may again refer to it. A frame is clipped on to the front of the headstock by two screws, and carries a tiny roller or "rubber" which can be seen in the figure pressing on the waved surface of the rose ring. As this rubber is on a stationary stud, the rose ring has to move continually to keep in contact with it, being held up to it by springs. Connected with this moving ring are two slides at right angles to each other; these slide in their guides in turn, in accordance with the direction given to them by the rose ring, with the result that the front slide exactly follows the motion of the ring. On the face of the front slide is mounted a second, carrying a nose screw upon which the work or another chuck can be fixed. By moving this last slide in its guides, and by rotating the nose screw by the worm or tangent wheel (Fig. 1), the work can be recentered without removing it. The right hand specimen in the background of Fig. 3 shows the effect of this. The central rosette was first cut by the aid of the rose ring. Then the work was put out of center by the side, and one of the outer rosettes cut. On the completion of this the work was rotated through one-eighth of a circle, and the next rosette cut, and so on.

We now come to the oval chuck by which the specimen lying in the front of Fig. 3 was cut. This chuck, which is used also independently, is shown as screwed to the front of the rose chuck, but as the weight is too great to be borne without vibration, an additional bearing is mounted on the bed to support it, and also to furnish a point of attachment for the stationary portion or "ring" of the chuck. The nose of the oval chuck is carried on a slide, at the back of which are bearing pieces embracing a stationary circular cam mounted on the support. By means of two screws this cam can be placed more or less eccentric to the axis of the lathe, and the front slide made to move in or out in a horizontal plane at each revolution. By means of the wormwheel and tangent screw shown, the work can be reset, to produce a number of oval rose-turned patterns grouped around a center.

The specimen shown on the lathe is produced by aid of the spiral apparatus. An amateur's lathe usually has no leading screw, but in place of this there is used the screw of the slide rest, which is driven from the tail of the mandrel through a side shaft and a Hooke's joint. By this device cylindrical, taper, curved, and surface spirals or screw threads can be executed. It is, however, essential that the first part of the shaft should stand at the same level as the screw of the slide rest; this is subject to variation, as an interesting variety of effects can be gained by raising and lowering the cutter. Hence, the "spade" bracket carrying the shaft is constructed so that it can be elevated and depressed. It forms the center of a long slotted arm in which change wheels can be mounted to cut any desired screw.

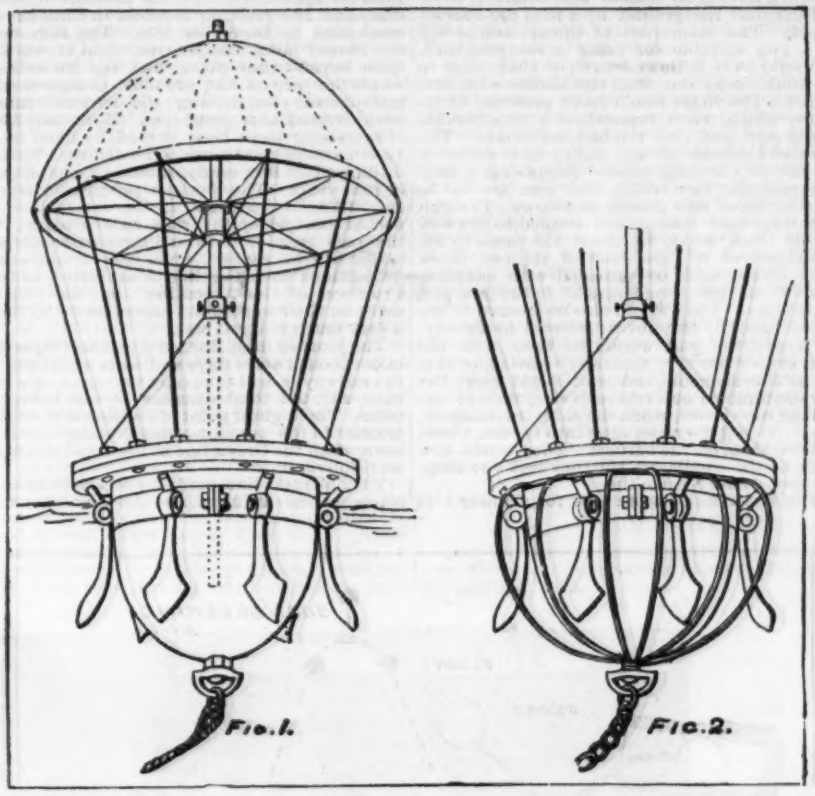
It very often happens in ornamental turning that the work is divided into segments, each of which is to be treated separately. Hence it is most important that the cutter should not encroach on the neighboring segment, and that the work should cease to advance the moment one segment is completed. This result is usually attained by means of the division plate, but the apparatus shown by Fig. 2 prevents all possibility of errors, to which the most careful workman is sometimes liable. The lathe before us is fitted with automatic apparatus which turns the mandrel through a given distance, and then throws the feed out of action. On the rear of the V pulley there is cut a wormwheel; into this there gears a worm, mounted on a shaft, which carries another wormwheel at its extremity (Fig. 2). This wheel is driven by a worm and a V pulley, by a band from an overhead drum. As long as the second worm is in engagement the mandrel revolves, but as the entire gear is carried in a pivoted bracket, the engagement can be easily broken. A screw constantly presses the worm out of gear, but its efforts are resisted by a hook or catch that takes hold of the bracket. When this hook is engaged the feed motion is in operation, and continues so until a stud fixed in one of a ring of holes (Fig. 2) on the edge of the wormwheel comes in contact with a tappet on the pivoted frame, and trips the catch. The worm then moves out of gear, the mandrel is arrested, and the driving band thrown so slack that it ceases to drive. By a very ingenious arrangement of the mechanism the effect takes place automatically equally well whether the mandrel is running backward or forward. When used for continuous driving, the apparatus may be instantly disengaged by a touch upon a lever. This patented device is quite new, and is likely to save amateurs from endless disappointment, for there is nothing more dispiriting than to spoil an almost finished piece of work by a false cut. In conclusion we have only to add that most of the novel features in this lathe are the invention of Mr. George W. Budd, manager to Messrs. Holtzapffel & Co., whose name is a guarantee of the splendid quality of the work and material.

LIFE SAVING DEVICES.*

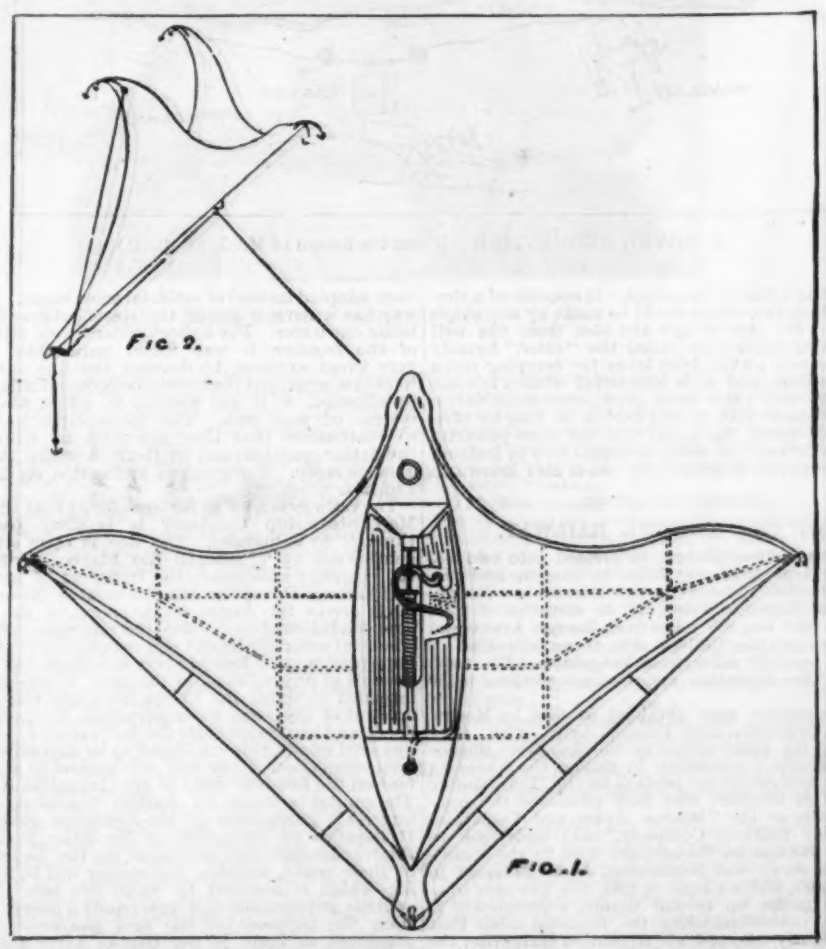
MR. JOSEPH C. FERGUSON sends us designs of an invention which consists of a buoy, to which are attached grapnels that hang loose all round it. When the buoy reaches the shore, no matter on which side it rests, two of the grapnels must fall to the ground, and with the weight of the buoy above them take hold, when the rope is pulled on board the stranded ship. The buoy is made in two pieces. The bottom is "boiler" shaped, and has a flange round the top. The upper half is conical, and is fixed to the lower by means of bolts through the flanges. The buoy is made of metal, and if necessary, it may have a covering of cork and an outer jacket of copper. This is intended to reduce any danger of the buoy collapsing by getting a hole knocked in it on any sharp rock. Mr. Ferguson also suggests that the buoy should be filled with not very large India rubber air balls, which would help to keep it afloat in case of accident. The top is of the nature of a parachute and is fixed on a standard which passes up through the buoy, from the base to the apex. The cover of the parachute would be of canvas or other suitable material. It is extended by an arrangement made on the same principle as a bicycle wheel, the canvas being secured to the rim. The stretcher is put on the standard from the top and falls to its proper place, where it is secured to the standard by a set screw. The eye at the top of the canvas is fixed to the top of the standard. The parachute is also braced down by cord or wire to rings in the flange. Fig. 2 shows a guard or cage which may be fitted to the buoy, and would help to protect it in the water, and when the water edge was reached the wind, still acting on the parachute, would easily drag the buoy well up on the shore, "the guard forming a sort of skid which would make it slide easily."

Mr. Joseph Chatfield sends us a number of sketches of his invention, which consists of a buoy towed to the shore by means of a kite. Fig. 1 shows the kite in flight, Fig. 2 gives an idea of its detail. It is arranged so that a time fuse disconnects the flight line of the kite and brings the kite to the ground when it has dragged the buoy sufficiently near shore. The buoy would carry a heavier line, and grapnels are attached to the wings of the kite.

We have been able to illustrate hardly a tithe of the designs received, but we give to-day a sketch of a novel suggestion by Mr. J. Southall. He says the object he has aimed at is the making of the establishing of communication from the shore a matter of greater certainty. This he would do by using two floated ropes



A BUOY WITH GRAPNELS AND LIFE LINE. (From designs by Mr. Joseph C. Ferguson.)

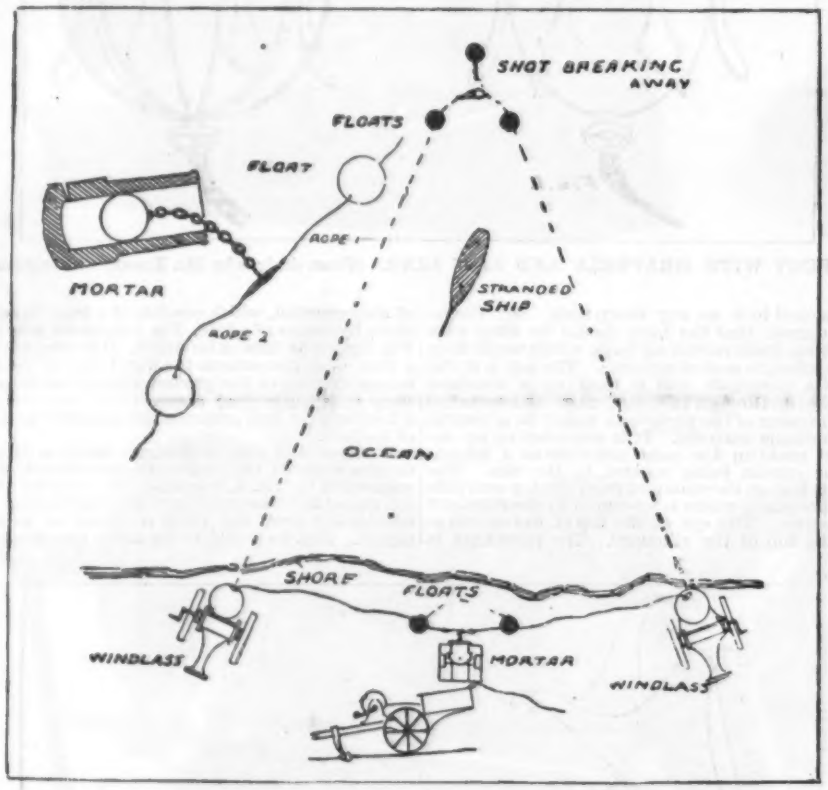


A KITE OR DRIFT BUOY. (From sketches by Mr. Joseph Chatfield.)

* Continued from SUPPLEMENT, No. 871, page 13917.

thrown in the form of a loop, as shown in the sketch, beyond and around the ship, so that when drawn in they will of necessity be bound to come to the vessel, and "therefore into the hands of the shipwrecked crew." To accomplish this he would provide two light trucks on wheels, each carrying a coil of rope wound in a box or on a reel, and a simple windlass, to which the end of the rope is fastened for winding in, the handle of the truck having an anchor arm under it to be driven rapidly into the ground by a hammer carried on the truck. The other part of the apparatus will consist of a gun suitable for firing a cast iron shot. This shot would have a short length of chain cast to it, which would hang out from the muzzle when the gun is loaded. The chain would have provided at its end a device which, when exposed to a considerable strain, would part and free the ball and chain. The device has also a shackle at the end of it to secure it rapidly to the two floating ropes. Supposing a ship to be in distress, the two trucks and gun are to be brought to the shore and placed as follows: The gun facing the ship, and loaded and trained to fire well over it. One truck would be about 150 yards to 200 yards on each side of it. The ends of the two truck ropes (which would each be provided with coupling shackles and floats) are to be brought to the gun and shackled together. They would also be secured to the chain of the shot by the device referred to already. All being ready, the gun would be fired, with the result that, even if not very accurately carried, or if it is affected by the elements, the shot would carry the ropes (now continuous) out, one each side, wide of the ship till all the rope is out, when the shot, traveling on, breaks away, letting the ropes drop into the sea, where the floats keep them on the surface. They would now be drawn in by the windlasses till they met the ship, where the crew would receive them.

Mr. R. B. Marston sends us an idea for a water kite for conveying a line to the shore. It consists of a simple float of planks, which could be made by any ship's carpenter. He says he got the idea from the well known fishing implement called the "otter," formely used extensively on the Irish lakes for carrying out a line from a boat, and it is wonderful what a life-like and strong "pull" this otter gives, even when only a bit of deal board, with a lead keel 18 in. long by 10 or 12 deep. Of course, the larger it is the more powerful it is. The "otter," he adds, is illegal now in Ireland, but is still used by poachers; its use is also known in Norway.



A NOVEL SUGGESTION (From the design of Mr. J. Southall.)

THE TRANSANDINE RAILWAY.

The Transandine Railway is divided into two sections—the Argentine, 108 miles in length, and the Chilian, 40 miles. The respective termini are Mendoza, on the Argentine side, at an elevation of 2,376 feet above the sea, 650 miles from Buenos Ayres, and Santa Rosa, on the Chilian side, at an elevation of 2,739 feet, and 80 miles from Valparaiso. The total length of the Argentine and Chilian sections is 150 miles.

The concessions were obtained in 1874 by Messrs. Clark, of Valparaiso and Buenos Ayres, who, after completing the construction of the line from Buenos Ayres to Mendoza, succeeded in raising the necessary capital for the Argentine portion of the Transandine road; and in October, 1886, they promoted the company known as the "Buenos Ayres and Valparaiso Transandine Railway Company," and undertook to construct the line for the amount fixed by the concession. The work was commenced from Mendoza in January, 1887, and on June 6, 1891, the line was completed for traffic up to Rio Blanco, a distance of 75 miles, and, notwithstanding the financial crisis that has so seriously affected all Argentine enterprise, the construction of the line is making progress, and by the end of this year it will probably be finished up to Punta de las Vacas, 88 miles from Mendoza, and only 20 miles from the frontier of Chili, a distance that can easily be traversed by carriages over a good road that has been constructed. In the course of next year the locomotive will reach Puente del Inca, 99 miles, leaving only 9 miles of the Argentine section to be finished.

On the Chilian side work was commenced at Santa Rosa on April 5, 1887, but on account of the financial crisis and the political troubles in Chili the work was suspended in December, 1890. The rails now extend for twenty miles, but a great deal of work has been done beyond that point, and the materials for the whole line are on the ground. Complete mechanical installations for drilling the summit tunnel have been erected at a great cost. More than 3,000 meters of tunneling have been drilled by hand labor, about 11,000 meters remaining to be drilled. This, with the drilling plant now ready, should be completed in three or four years. The work is progressing from twenty-two different headings at the same time. It is expected that when the rails have reached the foot of the pass from both sides a large passenger and cattle traffic will be carried, which will attain considerable proportions when the line is completed, as the Andine Provinces of the Argentine Republic will be able to carry on their import and export traffic by this route at a very much reduced cost.

The journey from Buenos Ayres to Valparaiso by sea takes about twelve days and costs about £40, while by the railway it will take only two days, at a cost of less than £12, the total distance by rail being about 880 miles. The highest point of the line is 10,500 feet, at the frontier in the summit tunnel, being about 3,000 feet lower than the Oroya line in Peru and the Antofagasta and Bolivia line.

To make the line perfectly secure from any possible interruptions during the winter a series of tunnels has been adopted instead of artificial snow sheds. The railway has a narrow gauge, the space between the rails being one meter. For a short distance on either side of the frontier it was found impossible, without very great expense, to develop the line sufficiently to obtain gradients that could be economically worked by adhesion, so it was decided to adopt the "Abt" system of rack rails. The locomotives have been so constructed that they can work by adhesion on the flatter gradients and by the rack where the gradients are steep. The greatest inclination on the line is 1 in 12½.

The railway is now so far completed that the Royal Mail Steamship Company is booking passengers through to Valparaiso. The line is open on the Argentine side for 77 miles to Rio Blanco. From there the company undertakes the transport of passengers and luggage during the summer months (November to May) across the Andes to the point of the Chilian Transandine Railway, where the rail route is resumed. The final accomplishment and completion of this great enterprise may be looked upon as certain, but it is impossible at present to name the time. It was originally intended to finish the line in five years' time, but on account of obstacles to construction in the shape of floods and revolutions and the bad state of Argentine financial affairs, this was found to be impossible. The final completion of the line will depend to a great extent on the financial state of the Argentine Republic. The capital is found by English financiers, and the interest is guaranteed by the Argentine government. It depends on the ability of the latter to carry out their guarantee, and, moreover, on the improvement of their credit, whether the money will be forthcoming which is required to finish the line. The Argentine government has just issued a decree authorizing the payment of the first guarantee account presented to them by the Buenos Ayres and Valparaiso Transandine Railway Company up to December 31, 1891.

PASSENGER CAR PAINTING.*

By Robert M'Keon.

OUTSIDE FINISH.

The trucks, steps and platforms of the car we prime with any good mineral paint, coating all parts both inside and out, as well as all iron work. And there being so large an amount of iron work on the trucks, we never use lead on them, as it will not wear as well on iron as a mineral paint. We putty up and glaze over all roughness on the wood and iron where exposed, then sandpaper and apply a coat of the standard truck color of the road. It is not necessary to coat the inside with this, as the priming and the third or last coat will be sufficient. Sandpaper lightly and give a coat of varnish color over the entire trucks, both outside and inside, also coat the steps and platforms with the same number of coats. The varnish color is made with equal parts in weight of the japan color used and varnish.

There are different shades of color in use for the finish of trucks on a passenger car; it is generally darker than the body color, and that which sets off a body color of Tuscan red, and harmonizes well with it, is olive green or a Pullman color. This is striped with a half inch line of black or Indian red, if striped at all, but striping on trucks or steps is unnecessary on an ordinary passenger coach; whatever the style of striping is on the trucks, the steps and end rail of the platform should be finished to correspond, being the same style of finish. One heavy coat of varnish on the trucks and steps is all that is required.

The truck wheels being new, or old ones well cleaned with naphtha and cotton waste, I give them two coats of Venetian red ground in japan and one coat of varnish. Wheels painted red will look well for a trip or two on the road, or while standing in the yard before the car goes into service, but very soon become dirty, and unless they are regularly cleaned at terminals, which is seldom done, they had better be given a coat of cheap black and let go at that.

The platform railing being new iron, or scraped clean and free from all old scaly paint, we give it a coat of Prince's mineral paint so as to dry flat, but with sufficient oil in it to dry firm. If they are rough, a second coat of the mineral should be given quite heavy, but to dry flat; then sandpaper thoroughly and apply a coat of drop black in japan and finish with a coat of varnish. All truss rods, air and gas cylinders, check chains, etc., under the body, have one coat of heavy lampblack varnish color; the crown moulding of the body and upper deck is coated with drop black and varnished, although this is not done until after the roof is painted.

PAINTING TIN ROOFS.

We now come to the painting of the passenger car roof, and we consider this of as great importance as any other part of the car. And how to paint a tin roof, and have it do good service, is something that is more difficult of solution than many would suppose on first thought. I have heard this subject reviewed at several painters' conventions, but nothing definite was arrived at in any of the discussions I have listened to. We all know that tin has a bright surface, and that ordinary paint, as applied on wood, will not adhere to it; there is nothing for it to cling to; it is like coating over a piece of glass; and the question may arise, how should the bright surface be treated before receiving the paint? We have heard it advocated that it was a good plan to let the tin rust before painting, but I do not know how this would operate, whether beneficially or otherwise, as I have never given it a test, and would not take any stock in the theory that the rust has a tendency to increase adhesion of the paint over it any more than rusted iron would hold the paint. The bright tin does protect the iron under it, and that is what it is put there for, and why should it be allowed to rust before being painted? Still we have heard of this plan being adopted by both car and house painters, and they claimed that paint would adhere better to the rusted surface of the tin.

I do not, from my own experience, believe that any previous preparation is needed before the paint is applied, with the exception that after the tinners have completed the roof we take a putty knife and scrape the resin off the seams; then with naphtha and waste or a sponge, wash off the entire roof. This is done for the purpose of removing the greasy substance that will be found on it after the roofers have left it, as well as to remove the acid which is frequently used for soldering in place of the resin. When all is wiped off clean we take Prince's metallic paint in paste form, or Venetian red that has been ground stiff in boiled linseed oil, and thin down with equal parts of boiled oil, japan and turpentine, apply the priming coat quite light with just sufficient pigment in it to cover, well—say one pound of the paste paint to three pounds of vehicle—then give it time to dry. There is always plenty of time for painting a passenger car roof while the car is in the shop, and it is very important that this coat should dry hard; give it from three to five days, then examine it and you will find a good foundation and reasonably hard on which to apply the following coats of paint. The second coat we mix the same as the priming, putting it on about the same thickness. When well dried prepare the third coat with the same proportion of the paste paint, but using only oil and japan—that is, to one pound of pigment use two pounds of boiled oil and one pound of japan. No turpentine in this coat. Put the several coats on lightly, brush on well and spread evenly; it is not the heavy body of paint that wears the best, but it is the vehicles that give it the durability, and no more pigment is necessary than just a sufficient quantity to make a covering body on each coat, and the proportions given I have found to give the most satisfactory results.

Why does the paint on passenger car roofs crack and flake off in blisters when repainted several times? It is undoubtedly owing to the thick body of paint on them, and the vibration of the tin opens up the cracks in the paint, which sucks in the dampness and wet, and by lying in those cracks will soon work through and rust the tin, and finally scale off the paint. So it is very evident that the reason paint on tin roofs does not wear better is due to the heavy coatings of paint

* From *The Painters' Magazine.*

applied to them. The oil will protect them and we should use the pigment sparingly, giving a new roof but three coats; and when the car comes in the shop once a year for revarnishing, give the roof one coat only, a light one as before. It may be necessary to give an extra coat to the projecting ends of the roof, as these are worn off by the constant beating of the hot cinders against them from the engine; but let what paint is put on be well spread with the brush and not allowed to lie heavily or in runs in the seams, for these are most liable to give away and break if a heavy coating is left on them.

INSIDE FINISH.

For the inside finish of the car it is necessary to prepare a filling that will dry hard and somewhat elastic; it should be tough, but not oily, nor should it dry tacky, but mixed so that it will make a hard and compact surface. It should be prepared with but a small portion of turpentine. There are several fillers in the market claiming to give good satisfaction, so far as filling the wood thoroughly, and they may be durable, although we never gave any of them a trial, as I always preferred to make my own. Take corn starch in sufficient quantity to make the filling for the entire inside of the car, put it in a pail and add to it equal portions in weight of raw linseed oil, japan gold size, and inside car finishing varnish. Mix it well into a thin paste, run it through the paint mill loosely, so as to mix the corn starch and vehicles, then thin down the quantity required for daily use with turpentine to a free working consistency. The woodwork being well dusted off, apply a full coat with a rather elastic brush, so that a heavy coat can be given or one that will cover the surface solid. This will set on all flat work and panels in fifteen minutes so that it will be ready to scrape, which we do with a broad knife on all large surfaces, scraping downward so as to press the filler into the open grain and pores of the wood. When this is done take a piece of moss and rub the work lightly, which removes any loose material, and this must be done before the filling has dried hard; in fact, the panel must be completed within an hour, or the filling will get too dry and be difficult to remove from the work. If the wood is coarse-grained or porous, such as ash, oak and bird's eye maple, we give a second coat of filling the following day, and it pays us well, as this extra coat saves a coat of varnish. It is said that vegetable filling will soon decay in the wood, especially that which is made with corn starch, but we prevent that by the use of a large portion of raw oil and varnish, which, with the japan gold size, forms a solid ground on the filling and one that the varnish will not sink into, as it will on a filling made with a less quantity of elastic liquids and pure turpentine. Let the filling coats dry forty-eight hours, then sandpaper down lightly to clean up the surface with No. ½ sandpaper, and see that no spots of the filling are left on the surface, as this will mar its beauty when the final finish is put on. Dust clean and apply a very light coat of amber gum shellac for all dark woods, but for very light wood, such as maple and white ash, use white shellac if you desire to keep the work clear. One coat of shellac is sufficient for any finish, and, in fact, I have done the best work without any shellac whatever, and have applied my varnish directly over the filling on more jobs of work than I have applied the shellac. I believe there is less liability to crack, as we have by this plan no brittle substance under our varnish to break loose, although the one light coat will not do any serious damage and does hasten the finish of the job.

There are several varieties of woods used for the interior finish of passenger coaches, such as mahogany, cherry, maple, ash and oak, but the present style of finish is mostly in quartered oak, which is a new departure, and presents a very fine finish. All filled and varnished woods are liable to become darker by age; the darkening is caused not alone by the material applied to them, but by exposure to light.

Whatever puttying is necessary should be done after the shellac coat is given, or if no shellac is used, then after the first coat of varnish, when the putty can be easily matched to the color of the wood. In making putty for all natural or hard wood finish use no lead, as it is liable to change its color, but make your putty with whiting and color it to the shade required with umbers, siennas and ocher, which, if used in the proper proportions, will match any of the woods used in inside car finish. Get as little putty on the surface as possible; simply fill the hole or defect, leaving the putty a little flush, and it will sandpaper down level. In mixing the putty use but a small portion of raw oil, or say about equal parts of oil, japan gold size and inside finishing varnish. This will dry hard, and with the varnish in the putty it will not absorb the varnish applied over it, which changes the color of putty if it is made without the varnish. We have often noticed inside finish in cars that had been out but a few months, especially on light woods, that showed the putty very plainly, which was undoubtedly matched to the wood when the puttying was done, but on investigation I have always found that the putty was made with lead, and was brittle or short-grained and had not elasticity sufficient to prevent absorption of the varnish. Of course, as stated before, the wood will gradually grow darker with age, and therefore it is better to have the putty a shade darker when the wood is matched.

The varnish best suited for inside finish is one that dries in forty-eight hours. Give three coats of this where a first class finish is desired, sandpapering on the first coat pretty thoroughly with No. ½ paper, and hairing off on the second coat to deaden the gloss before giving the third coat; this gives us a good body of varnish to rub down on. The work having stood three days, after applying the last coat of varnish, we proceed to rub down evenly with No. 0 ground pumice stone and water, using felt rubbing cloth and a stub of a bristle brush for corners of panels, mouldings and fluted work, also carving. Although very little carving is now being done on the prevailing style of finish, that, with the decoration on the inside body of the car, is gone out of date, as a plain substantial finish is considered neater and less expensive, as well as being more easily kept clean.

After rubbing, and when the car is fitted up ready for the road, go over the entire surface with raw linseed oil, wiping off perfectly dry with white cotton waste, giving the final wiping with a new chamois skin. This oiling makes a good many edges that may be rubbed through, and gives an even luster, and the chamois skin takes up any oil left on the surface after it has been wiped with the waste.

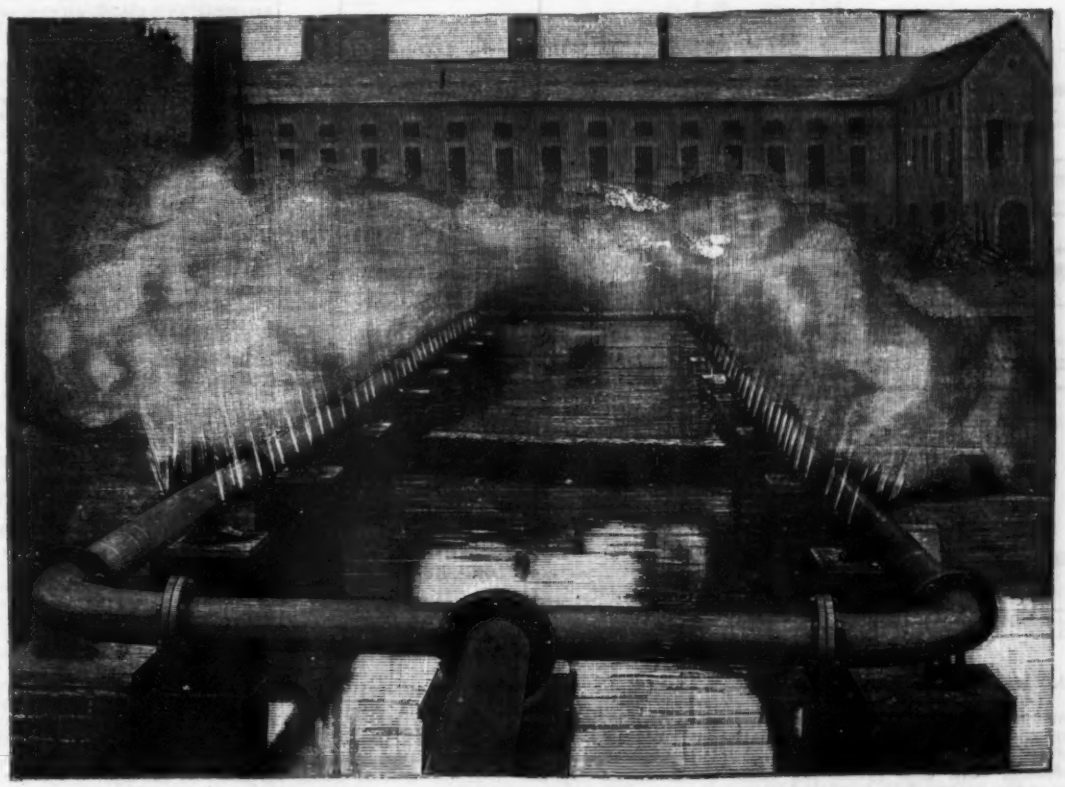
In the formula and method of finish given above, I wish to impress on all the importance of filling the wood properly at the start, saving as it does both in labor and material on the subsequent coats of varnish, and if filling is properly mixed it is very beneficial to the wood. The most important consideration is to fill the open grain of the wood perfectly, so that when the job is completed it will present a smooth surface, and it can be finished with an egg shell gloss, or, if preferred, a little extra labor with oil and rotten stone will give it a good polish.

The sash and inside of the blind frames we fill the same as the other inside work, and the same number of coats of varnish, and rub down the sash, but not the blinds; these we hair off to deaden the gloss. The blind slats and outside frame of the blind we prepare by giving a coat of three parts raw oil and one part turps, which is a better protection to them than shellac would be, as they are exposed so much on the outside to the weather. This will dry in three days, when we give three coats of the outside body finishing varnish, and you will have a blind that will do good service, and hold its color better than where it is finished on the outside with the same method as the inside of the sash is, which is usually the case. And in a short time the lower half of the blind becomes stained and weather-beaten on the outside from exposure. The chairs in the car are wood, and those are finished the same as the other woodwork, but are not rubbed. We leave all work below the window stools in gloss; it is much better, and saves considerable labor, although a light rubbing with curled hair, just sufficient to deaden the luster, may be given it.

If the floor of our car is a new one, I should not put any paint whatever on it. I think painted floors are a great expense, with no corresponding amount of benefit, and I should give a new floor, while clean, a coat of raw oil, put on quite warm, so it will penetrate well into the wood. Put this on late in the day, and next morning it is all dried in, and when time will allow of it and not interfere with the work, give it a second coat, quite hot, as before, which fills the pores and grain of the wood. When putting on the second coat, have a man follow up with a bunch of moss, and rub it in well, then wipe dry, and we have a floor that will outwear any of the painted ones, and will look well for a long time; it will clean off easily, and we have no paint on it to scuff off with the feet. Just before the car goes into service, and when the fitting up is completed, give the floor a good cleaning with a weak soap, and follow up with a coat of oil, which should be wiped off perfectly dry. For old passenger car floors that are badly worn, we must give two or three coats of paint, so that they may go out looking clean and neat; and for a floor color a warm buff is preferable, and more in harmony with the surroundings than any other color that could be given.

APPARATUS FOR COOLING WATER OF CONDENSATION.

THE problem of cooling water of condensation is one of the most important of those that manufacturers have to deal with.



APPARATUS FOR COOLING WATER OF CONDENSATION.

Up to the present such water has been treated in immense reservoirs, or by means of fascines, or even by means of circulation canals. Those processes have numerous inconveniences, the most serious of which is the imperfect cooling of the water. Moreover, reservoirs, apparatus, or canals are very costly and occupy too much space.

The new coolers that the Messrs. See, of Lille, have just patented are of remarkable simplicity. They consist of nozzles through which the water is projected in a fine spray. The liquid, in a state of extreme division, on coming in contact with the air, becomes sufficiently vaporized to cool the mass from 18° to 25°, according to the temperature of the water coming from the condenser.

With this apparatus but one-tenth of the water is lost, so that nine-tenths can be used again, and is sufficiently cool to form an excellent vacuum in the condenser.

Numerous applications of this apparatus have already been made, the most important of them at Roubaix and Tourcoing. At present the Messrs. See are installing a 3,000 horse cooler at Launoy. There is one of 2,500 horses at Madrid, and one of 1,200 horses at Liege.

These apparatus, far from presenting the unsightly aspect of the old systems, produce a very ornamental effect, especially in a large court yard or in a garden. That of Launoy, situated in the center of a park, produces a magnificent effect. As they occupy a very limited space, they may be placed above the buildings, so they are in nowise cumbersome.

As for the net cost, that is infinitely less than that of the old systems.—*Le Genie Civil.*

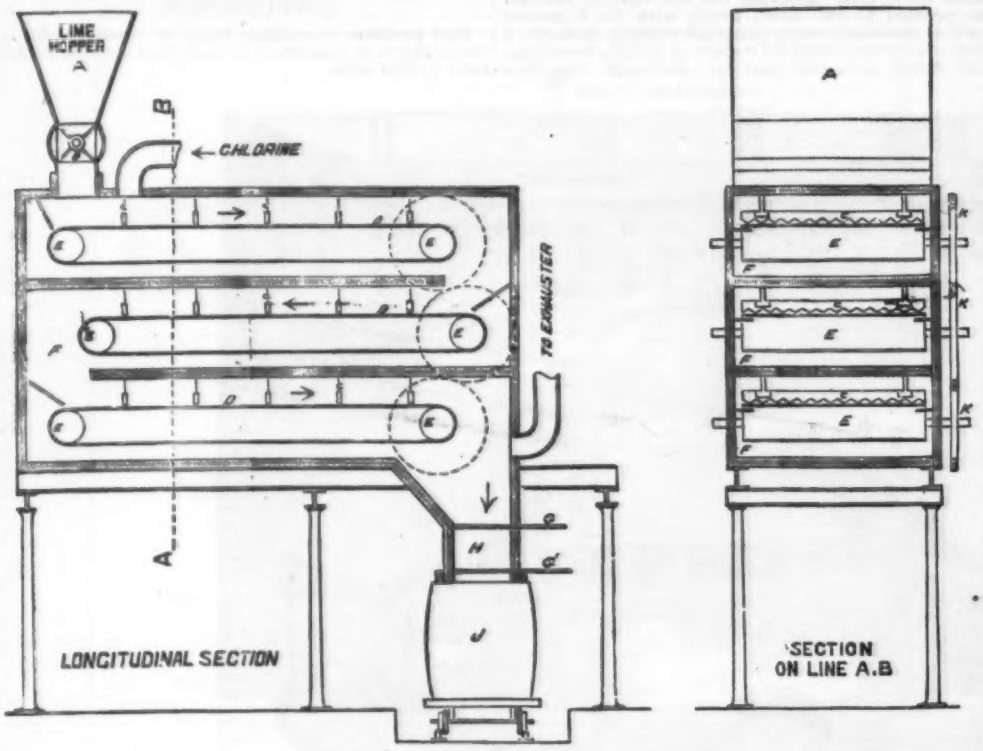
IMPROVEMENTS IN THE PRODUCTION OF BLEACHING POWDER.

ONE of the chief points upon which the arguments in favor of shorter hours in the chemical trade are hung is the arduous and trying occupation of those engaged in the production and packing of bleaching powder. Any improvements which will enable manual labor in this particular department to be reduced to a minimum will, therefore, in the majority of cases, be eagerly sought for by managers, for innumerable reasons.

We take this opportunity of calling the attention of those whom it may interest to the recent patent of Messrs. J. M. and A. Mills. This patent consists virtually of an automatic bleach chamber. Although the apparatus is designed to effect the saturation of any solid material with gases or vapors, we shall confine our attention to the application of this apparatus to the absorption of chlorine gas by lime, for the production of bleaching powder.

For this purpose a chamber or series of chambers is constructed of any suitable material, preferably of slate slabs. In the chamber, or in each of the chambers of a series, an endless belt is placed, of any suitable material, preferably of asbestos cloth, which has been found suitable in every way, there being no difficulty in making the bands, which revolve upon two or more drums or cylinders. Upon the roof of the first chamber a hopper is situated to receive the material intended for saturation, and at the bottom end of the last chamber is a receiving chamber into which the material falls after saturation. The endless belt is actuated by any mechanical means, such as spur gearing or any convenient method.

The hopper into which the material to be saturated is placed is fitted with an adjustable admission valve, so arranged that the quantity falling through upon



the traveling belt can be increased or diminished at will.

Depending from the roof of each chamber at convenient distances, a number of combs is fixed, for the purpose of turning over the material as it is being carried along by the traveling belt, thus presenting continual change of faces in the material to be acted upon by the gas.

The apparatus, as will be seen from the drawing, is so simple that it is quite unnecessary to give any explanation of the method of working, the following brief references to the letters in our illustration being quite sufficient. A is the hopper receiving the lime. B is an admission valve, which works automatically, and is so arranged that the quantity of lime admitted can be increased or reduced at will. C are the fixed combs whereby the lime is constantly turned so as to present a fresh surface, and also the depth of the layer of lime on the conveyer is regulated. D are the traveling belts of asbestos. E the cylinders upon which the same revolve. G and H are plate slides for admitting the saturated lime to the receiving cask, J, while K are the spur gear wheels for driving the asbestos belts.

It will also be seen that the chlorine gas enters with the lime, being drawn through the plant by an exhauster.—*Chem. Tr. Jour.*

HUMAN ELECTRICITY.

THE investigations of physicists make it highly probable that all movements of matter, even those of a molecular character, are linked with electrical phenomena. Friction, even the brushing of the wind over the surfaces of things, the falling of raindrops from the sky, the action of light and heat, the production of flame, and all the molecular chemical changes that are silently going on in inanimate nature, are associated with changes in the electrical state. It follows that our modern methods of producing electricity by friction, by induction, by heat, by chemical action, are but specially contrived imitations of processes carried on throughout the ages. Such considerations would naturally lead one to expect that electrical phenomena would also be associated with those finer molecular changes on which life depends, and that it is only a matter of experimental detail to demonstrate the existence of an animal electricity. It seldom, however, happens in science that we see far before us, and even acute minds miss recognizing facts that to their successors are everywhere apparent; the usual procedure rather is that we look backward and find an intellectual satisfaction in tracing the gradual unfolding of any department of knowledge, while we have some difficulty in even imagining a time when such knowledge did not exist.

All this is true of animal electricity. Thus electrical fishes have been known from early times. The benumbing effects experienced by a fisherman in the Adriatic, when he drew a torpedo from his net, were familiar to Aristotle. An Egyptian inscription, executed about 5,000 years ago, shows figures of the well known malapterurus, the thunderer fish of the Arabs, a fish having such electrical properties as could not have escaped the attention of the ancient people. It was not till 1778, however, that Walsh first demonstrated that the shocks of the torpedo were truly electrical. Thirteen years after—namely, in 1786—Luigi Galvani, professor of anatomy and physiology in Bologna, noticed that the limbs of recently killed frogs became convulsed when brought near a frictional electrical machine in action. This famous observation marks a new epoch in the history of science. He found that the convulsive twitches occurred only when a spark was emitted from the conductor, and only when some metallic substance was in contact with the nerve. Recognizing the sensitiveness of the frogs' nerves to electric shocks, he used them in investigations into the phenomena of atmospheric electricity; and on the 20th of September, 1786, he suspended, by copper hoops, three frogs to the iron trellis work on the roof of his house, and saw, as the limbs were blown about by the wind, that convulsions occurred when the toes touched the iron railing. This proved that an electrical machine was not required, but while Galvani recognized the fact, he missed the true explanation. We now know that the twitches in the frogs' legs were caused by electrical currents that came, not from the sky, nor from the animal tissues themselves, as Galvani imagined, but from the contact of the copper hooks with the iron railing. About this period the old and ever-recurring question of the nature of life was in an acute stage, and it is not wonderful that the physiologist of Bologna thought, from this and numerous other experiments, that he had detected the "nervous fluid," the something which, if not life itself, was at least inseparable from it. This is now an old story, and all the world knows that the famous controversy between Galvani and his followers and Volta, the professor of natural philosophy in the University of Pavia, led to the invention of the voltaic pile in 1799, and still more to the discovery of the production of electric currents by the contact of dissimilar metals, more especially when one of them is acted on chemically by certain fluids. For a long time the brilliancy of the results flowing from the investigations into voltaic electricity threw the discoveries of Galvani into the shade; but by and by, as experimental methods became more delicate, it was found that there is in truth an animal electricity, the existence of which was doubted by Volta and his followers.

We know now that in spite of Galvani's primitive experiments the electric currents that caused muscles to contract were undoubtedly produced by the living tissues themselves. It was next to impossible, at that time of day, to prove the fact. The apparatus for the detection of extremely feeble currents had not been invented. The next step was made by Oersted, in 1820, when he discovered the influence of a current of electricity on a magnetic needle, and the construction of a galvanometer thus became possible. Five years later, in 1825, Nobili constructed such an instrument for physiological purposes, and by means of it he demonstrated that a current could be obtained from a frog's muscle. He prepared a frog, introduced its two legs into two glasses of salt water, placed in each vessel a strip of zinc, connected the two strips with the galvanometer, and obtained a deviation of the needle to the extent of 10° to 30°. He showed that Galvani was right in maintaining the existence of an animal electricity, while he was wrong in holding that the contact of two metals with the tissues gave a proof of this. On the other hand, Volta was right in his statement that the twitches of the frogs' muscles in Galvani's experiments were independent of an animal electricity, but he was wrong in denying, as he did, that electrical currents existed in the tissues. Matteucci, about 1837, enriched the subject by many beautiful investigations, and by joining the thighs of frogs in a special way, he made a living voltaic pile, which produced effects similar in character to the piles built up by physicists with disks of metals and intervening disks of paper or cloth. Then came Du Bois-Reymond, the present venerable professor of physiology in Berlin, and the successor of Johannes Muller, who was the intellectual godfather of such men as Von Helmholtz, Du Bois-Reymond, Virchow, Brucke and Reichert. In 1841 Du Bois-Reymond, who combines, as his ancestry would lead us to expect, Celtic fervor with Teutonic thoroughness, took up the subject of animal electricity with rare enthusiasm, and since then has labored on it with much success. One feels, after reading any one of his numerous monographs, that he has left little for the gleaners in this field of research. Electro-physiology has attracted many able workers during the fifty years that have elapsed since Du Bois-Reymond entered on it, and much has been accomplished, more especially in examining the properties of the electrical fishes. It may not be uninteresting now to inquire as to what can really be demonstrated.

In the first place, by using a sensitive galvanometer, or the ingenious capillary electrometer, a kind of electric manometer, invented by Lippmann in 1873, and by connecting tissues with the unpolarizable electrodes of Du Bois-Reymond (a contrivance by which contact can be made between the galvanometer or electrometer and the tissues without the risk of generating currents by chemical action), it can be shown that all living tissues show differences of potential at different points, or in other words, that electrical currents pass through the instruments when the tissues are placed on the electrodes. With such sensitive appliances, a bit of skin, a morsel of muscle or nerve, a fragment of such an organ as a gland, an eye, or a heart, show electrical currents. Although a normal muscle, absolutely uninjured, is isoelectric, that is, gives no current, because all points of its surface have the same potential, it is often impossible to place on the electrodes a muscle, or, indeed, any living tissue, so not to show currents by the movement of the needle of the galvanometer. Careful examination, however, proves that the strongest currents are manifested when certain surfaces are brought into contact with the electrodes. For example, in the case of muscle, the strongest current is obtained when one electrode touches the center of a transverse section, while the other touches the uninjured surface of what may be called the equator of the muscle, that is, a line encircling it in the middle of its length; and it can be shown that the surface is always positive to the transverse section. The same is true of nerve. If a frog's eye is placed on the electrodes, the center of the cornea is positive to the transverse section of the optic nerve and the internal surface of the retina is positive to its outer or choroidal surface. Again, if a small piece is snipped off the apex of the ventricle of a frog's heart, this surface is negative to any other surface, while the heart is at rest and does not make a beat. All of these currents are, of course, due to differences of potential; and as they exist while the tissue or organ is at rest, they may be called resting currents, and they are usually due to the injured surface undergoing molecular changes causing it to become a different potential from that of any part that has not been injured. If living matter has a flesh surface exposed by an incision, the surface begins to die, that is to say, it rapidly undergoes molecular changes, and the dying matter becomes of lower electrical potential than the matter that is not dying, so that if the dying surface is connected with one electrode while the non-dying surface is connected with the other, a current passes through the galvanometer from the non-dying to the dying. Another way of expressing the same fact is to say that any local injury to living matter always disturbs electrical equilibrium, because the injured part becomes very quickly of lower potential. Now, it is evident that chemical action, as occurs in dying tissues, will be greatest on the injured surface. We may suppose that this surface, acting like the zinc, the positive, plate in a Daniell's cell, generates currents which pass through the muscle to its surface, issue from the surface (thus the positive pole) to the galvanometer, and back from the galvanometer to the injured surface, which thus represents the negative pole. Such currents, therefore, are evidently not of much physiological importance, except that they differentiate between different planes of vitality.

But the case is different when the tissue or organ discharges its normal function. This will be readily understood if we examine what occurs in a contracting muscle. The normal function of a muscle is to contract; that is to say, there is a movement of its protoplasm by which it shortens in length while it increases in thickness. Now, suppose a muscle laid on the electrodes so that a "resting" current is manifested by the deflection of the needle of the galvanometer; let the nerve supplying the muscle be irritated so as to cause contraction of the muscle: instantly the needle of the galvanometer moves in the opposite direction, and it may pass even beyond the zero point. This is due to the generation of a new current in the muscle, in a direction opposite to that of the resting current. The proof is this: Let us compensate the resting current before causing contraction of the muscle, by sending a portion of a current from a Daniell's element in the opposite direction, so that the galvanometer is brought to zero, then cause the muscle to contract, and the new current—the action current, as it may be called—sends the galvanometer needle to the opposite side of zero. This phenomenon of a new current in the opposite direction is known technically as the negative variation, and it is of importance physiologically because it is the indication of changes occurring in the muscle that are associated with its contraction. It is a vital phenomenon, because it can only occur when the muscle is alive. The action current may be accounted for by supposing that at the nerve termina-

tions in the muscle there is some kind of local change, just as occurs on the cut surface of the muscle. This local action, probably chemical, generates a current which passes through the muscle in the reverse direction of that of the resting current; that is to say, it flows to the cut surface, passes out by it to the galvanometer, and returns from the galvanometer to the point of entry to the nerve. The cut surface, therefore, during the action current, becomes the positive pole, while the uninjured surface is the negative pole of the little muscle battery: exactly the reverse state of matters to what obtained while the muscle was at rest.

Early observations seemed to show that this negative variation was a kind of wave of negativity that swept through the muscle, and was over and gone before the muscle contracted; but recent experiments of Burdon Sanderson, in which he simultaneously photographed the movement of the muscle and the movement of the mercury in the capillary electrometer, demonstrate that the negativity extends into the time of the contraction, or, in other words, that the two phenomena go closely together. The electromotive force between the longitudinal and transverse sections of the resting gastrocnemius muscle of a frog is from 0·03 to 0·08 volt, and the negative variation may amount to as much as 0·04 volt.

Similar action currents occur in the nerves. A nerve has a resting current, but when the molecular disturbances which, for want of a better term, we call a nerve current pass along it, there is a negative variation.

Electrical phenomena may also be discovered in the central nervous organs. If we bring the electrodes of the galvanometer into contact with the surface of the brain, electrical changes occur when light falls on the eye. Recently Gotch and Horsley have explored the spinal cords with electrodes connected with the capillary electrometer, and they have found electrical variations in the motor strands of the cord when motor centers in the cerebral cortex were irritated. Thus, in a sense, they tapped the wires of the living telegraph system and got information as to the paths in the cord along which motor and even sensory impulses travel. It seems to be only a matter of experiment to discover electrical changes in all the cerebral nervous organs. Could we picture to ourselves the changes in the brain when its higher centers are in a state of molecular disturbance, as when one is thinking rapidly in a lecture, now adapting his words to his ideas, now thinking ahead as to what he will say next, now noticing the effects of his words on the audience, now becoming conscious that he is obscure, and again that he is succeeding in making things plain, now watching the clock and noting the inevitable flight of time—could we, in such circumstances of mental turmoil, examine the phenomena of the brain, we would, in all probability, obtain evidence of rapid changes of potential, and of currents flashing in a thousand directions, pursuing paths the intricacies of which are many times greater than if all the telegraphic and telephonic wires of London were concentrated in one vast exchange.

Take another illustration. Place a frog's eye on the electrodes; we at once obtain a resting current, as above indicated. Keep the little eye in the dark and the resting current becomes less and less as the tissues die; but allow light to fall upon it—even a flash of light lasting the thousandth of a second, or the light of a vesta at a distance of several yards—and there is usually first a positive variation, then a falling off, if the light is allowed to act; and, lastly, if the light is suddenly cut off, there is almost invariably a second (positive) increase, followed by a (negative) diminution of the current (Holmgren, Dewar, and the writer). It is highly probable that similar electrical phenomena are related to the action of stimuli on all the terminal organs of sense.

The skin of all animals shows a current passing from the surface inward. This has been supposed to be due to abrasion of the surface, and the skin current must be distinguished from that due to secreting glands in that organ. Thus the skins of fishes show a true skin current, although they contain no glands. The glands of the skin, however, produce currents, and it can be shown that when the secretory nerves of the glands are irritated there is a positive variation of increase coincident with the secretion of sweat. Such electromotive phenomena connected with secretion have been demonstrated in the pad of the cat's foot, which contains numerous glands, and also in the submaxillary salivary gland. Thus the phenomena of secretion are undoubtedly connected with electrical changes.

One of the most interesting demonstrations of electrical phenomena in living structures is that of the variations connected with the beat of the heart. If the heart of a frog be laid on the electrodes, so that one electrode touches the base while the other touches a cut or injured surface at the apex, the needle of the galvanometer immediately begins to swing backward and forward, and it is easy to show that the swings are coincident with the beats. This remarkable phenomenon has received much attention. It is almost impossible to trace the direction of the currents while the heart is beating; but if the rhythmic beat is arrested by applying a ligature around the heart at the junction of the sinus venosus with the auricle, as was first shown by Stannius, in 1852, it is then possible to bring about a single beat by stimulating the heart either at the base or at the apex. Suppose, now, that the heart was connected with the galvanometer, or still better, with the capillary electrometer, and that we stimulate at the base; there is contraction, the base becomes negative to the apex, and the next instant the apex becomes negative to the base. This is what occurs with a normal beat. On the other hand, if the apex is stimulated, the apex becomes first negative to the base, and then the base negative to the apex. Evidently, then, in a normal beat, the contraction commences at the base and travels to the apex. But the electrical change does not occur in the same phase throughout the heart at one moment; on the contrary, the wave of negativity travels to the apex. An instant afterward, however, the contraction change at the base has disappeared, while it still remains at the apex. At this moment the apex is negative to the base. There are thus two phases with each contraction, and the phenomenon is termed a diphasic variation. Hence the swinging of the needle of the galvanometer. It is driven alternately in opposite directions. Similar phenomena have been noticed in the isolated mammalian heart. By far the most beautiful demonstration of this kind, however, has been recently given by Dr. Augustus Waller, of St. Mary's Hospital, London. Using the capillary electrometer, he has succeeded in showing electrical variations in man, without the necessity of making even an abrasion of the epidermis. Deeply placed as the heart is in the chest, full as it is of blood, and surrounded by the chest walls composed of bone, muscle, and skin, yet by placing one electrode, say in the mouth, and the other on the left foot, or even by placing them on opposite sides of the heart on the chest wall, the electrical variations with each beat can be demonstrated. Each beat of the human heart shows different electrical potentials if two points are connected with the capillary electrometer, one on each side of an axis passing, roughly speaking, from the left shoulder obliquely downward to the right side. Thus the body may divided into two asymmetrical electrical districts, so far as the beat of the heart is concerned, one including the head and right upper extremity and the other the three remaining extremities.

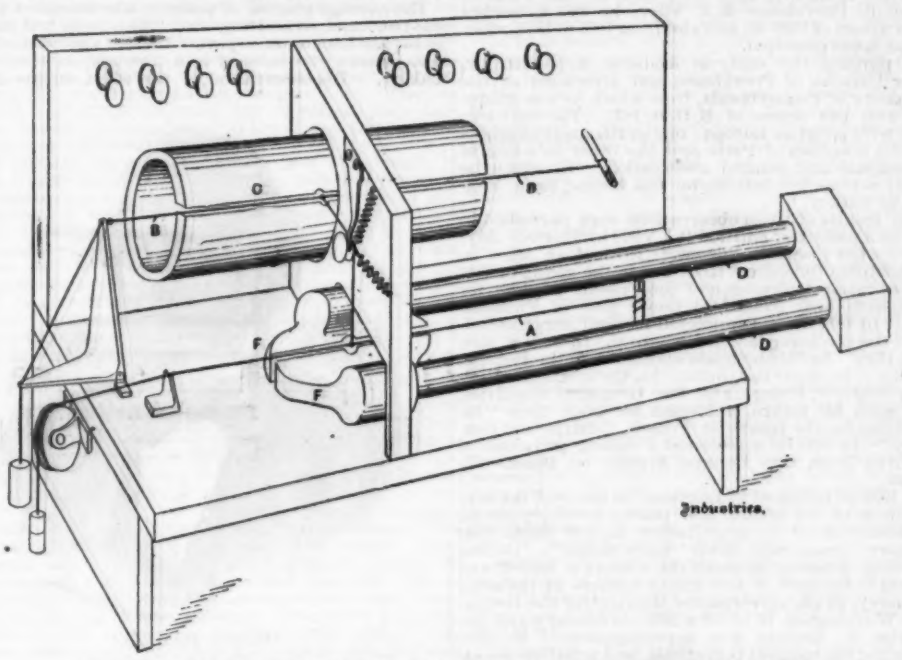
We have seen that electrical variations occur in connection with muscular contraction, and at once the question arises whether any such changes can be demonstrated in the human being. Suppose we have a very sensitive galvanometer. Take two shallow vulcanite troughs, and fill them two-thirds full with a three-quarter per cent. solution of common salt. Dip a perfectly clean slip of platinum into each trough, and lead wires from the strips to the galvanometer. Connect the two troughs with a strip of clean white blotting paper wet with the salt solution. As a rule, if precautions have been taken to have everything absolutely clean, no current will pass through the galvanometer. Then wash the hands thoroughly and place one in each vulcanite trough. At first there is usually a swing of the galvanometer, but it soon comes to rest. Then contract powerfully the muscles of the right arm. There will be a swing in one direction, say to the right. Next, throw the muscles of the left arm into contraction. The needle of the galvanometer will now swing in the opposite direction. By alternately contracting the muscles of the right and left arms the needle of the galvanometer can be caused to swing rhythmically. This experiment, first made by Du Bois-Reymond, demonstrating what he calls the man current, is of great interest. Careful examination shows that when the muscles of the right arm are contracted an electrical charge passes through the body from the right to the left arm, out from the left arm to the galvanometer, and back from the galvanometer to the right arm. When the muscles of the left arm are contracted, the reverse occurs; or, in other words, a current passes through the body from the contracting to the passive arm, and through the galvanometer from the passive to the contracting arm. Some have supposed that this is skin current, or rather a current due to a change in the cutaneous secretions, and it has been stated that it will not occur if the secretory nerves have first been paralyzed by atropine. As excitation of secretory nerves gives a positive variation, it is difficult to account in this way for the negativity that occurs in the actively contracting muscles, while the remarkable uniformity in the results that one, by careful experiment, obtains by alternately and rapidly contracting the muscles of the two arms is in favor of the view that the man current is due to electrical changes occurring in the muscles themselves.—*Fortnightly Review.*

THE MAGNETIC CURVE TRACER.

PROFESSOR J. A. EWING, F.R.S., contributed at the recent meeting of the British Association a paper descriptive of "A Magnetic Curve Tracer," which he had recently devised. It was intended in a simple and ready manner to trace the familiar magnetic curves which connect the magnetic induction in a piece of iron or steel with the magnetizing field brought to bear upon it, and which indicate at once to the eye the magnetic quality and characteristics of the specimen of metal concerned. To obtain the requisite data for these curves it was, of course, necessary to employ a galvanometer and a magnetometer—the former indicating the current strength in the helix employed to magnetize the iron; the latter revealing the value of the magnetic induction impressed upon the iron by the magnetic force to which it was exposed. In Professor Ewing's instrument, which is represented in the accompanying diagram, a galvanometer and magnetometer are combined, so that a single reading of the position of the spot of light reflected from the mirror of the instrument gives the ratio of magnetic induction to magnetizing field for the particular field strength employed and for the particular specimen under test. And if, by a proper current regulator, the values of magnetizing field be varied through a complete cycle, the spot of light will trace out upon a screen the curve which indicates the desired ratio at all points, and which in its entirety reveals the magnetic properties of the specimen.

In attempting to devise an instrument which would answer his purpose, Professor Ewing had recognized that it would be essential to have both parts of it as perfectly dead-beat as possible, and not finding any existing instruments satisfactory in this respect, he had gone back to an old "harmonic telephone," which, in conjunction with Professor Fleeming Jenkin, he had invented many years ago. The principle employed will be seen from the diagram. A A and B B are two wires suitably stretched. Each lies in an intense magnetic field. The former lies in the narrow gap between the two pole pieces, F F, which form part of the electromagnet, D D; the latter lies in the narrow gap cut out of the soft iron tube, C, which is magnetized by the current flowing through the wire wrapped longitudinally round the tube. A corresponds to the magnetometer, while B plays the part of galvanometer. The specimen of iron or steel to be tested is taken in the form of two small bars, and these, united at one end by a yoke, are thrust into the coils, D D. A constant current flows through the wires, A and B, which are repelled out of their respective fields to a greater or less extent when carrying this current.

The extent to which A sags *upward* on account of



PROFESSOR EWING'S MAGNETIC CURVE TRACER.

this repulsion will be proportional to the magnetic induction in the specimen under test, so that A acts as the magnetometer. The magnetizing current flowing through D D also traverses the electromagnet, C, and so the extent to which the wire, B, sags laterally will be a measure of the current magnetizing the cores of D D. Hence C acts as the galvanometer. The wires, A and B, are connected to the mirror, E, as the illustration shows, in such a way that the sag of A will tend to tilt the mirror up and down (about a horizontal axis), while the sag of B will tend to deflect the mirror laterally—*i. e.*, about a vertical axis. The mirror being suitably mounted on springs, is capable of free motion in both directions, so that its actual motion represents the combination of the two effects due respectively to the wires, A and B.

A suitable device is employed whereby the magnetizing current may be caused to increase from zero to a maximum, reverse, return to zero, etc. The spot of light will be seen to trace out on the screen (which may conveniently be ruled in squares like sectional paper) the familiar double S curves which are of such importance in various ways. The difference in quality of various kinds of iron and steel, the effect of lamination, etc., are well brought out by the instrument. It is possible to carry the iron under test through its cycle at such a rate that the path of the spot of light on the screen appears continuous on account of persistence of vision. There is no appreciable change of shape in the curve at different speeds—a point which is not without practical value. The effect of an air gap in the magnetic circuit was, Professor Ewing said, well known. It "sheared" the diagram over, giving it the appearance that would be produced if the ordinates and abscissæ made an angle with one another which was less than 90°. This error could easily be corrected in the instrument by rendering the angle between the wires, A and B, slightly less than a right angle. This correction was, however, of no great importance to dynamo builders, who seldom required absolute results.

Professor Ewing said that he had recorded the curves photographically, but the simplest plan was to follow the motion of the spot of light with a pencil. He claimed that the instrument might conveniently be employed in workshops, where when permanently set

up an accurate test could be made in a few minutes, the specimens being readily introduced and removed. He further pointed out that the instrument could conveniently be employed as an exceedingly dead-beat galvanometer, as an analyzer of alternate currents, and as a phasemeter.—*Industries.*

[FROM THE ALIENIST AND NEUROLOGIST.]

PLINY EARLE, A.M., M.D.

THE death of this distinguished American alienist, at his home in Northampton, Mass., May 17, severs the last link in the golden chain that bound the American psychiatry of the present to the past—a chain made of such sterling stuff as the Rays, the Brighams, the Butlers, the Gaits, the Tylers, and the Stribblings. But one reminder of this golden era remains with us yet in body as well as spirit, the venerable Joseph Workman, of Toronto, and he lives on the other side of that only line which divides American from British alienism—a geographical one. Dr. Earle was the last survivor of the original thirteen founders of the Association of Superintendents of American Asylums for the Insane, now the American Medico-Psychological Association.

Dr. Earle was one of the earlier contributors to this journal and encouraged it and showed his faith in it from its foundation by subscribing for ten years in advance. He was physically and mentally a handsome man, broad of observation, and keen and logical in reason—a style of man of which the profession in general of his native section and American alienism were and are justly proud, and they will venerate his noble memory.

From a biography written by Rev. A. H. Coolridge we glean the following history:

Dr. Pliny Earle was the fourth son of Pliny Earle, the great grandson of Ralph Earle, who came to Leicester in 1717. His mother was the daughter of William Buffum, of Smithfield, R. I. He was born December 31, 1809, and his childhood was passed in the home of his father, at Mulberry Grove. He was a pupil in Leicester Academy, and afterward in the Friends' School, in Providence, R. I., where he was a teacher in the winter of 1828–29, and also from 1831 to 1835, when he was made principal.

He pursued the study of medicine, first with Dr. Usher Parsons, of Providence, and afterward at the University of Pennsylvania, from which he was graduated with the degree of M.D. in 1837. The next two years were spent in Europe; one in the medical school and the hospitals of Paris and the other in a tour of professional and general observation, "in which he visited various institutions for the insane, from England to Turkey."

The results of these observations were published in 1840, in a pamphlet entitled "A Visit to Thirteen Asylums for the Insane in Europe." He had an office in Philadelphia for a short time, but in the spring of 1840 became resident physician of the Friends' Asylum for the Insane, near Frankford, now a part of Philadelphia. In 1844 he was appointed medical superintendent of the Bloomingdale Asylum for the Insane, in New York City. In 1849 he made another tour in Europe, visiting thirty-four institutions for the insane in England, Belgium, France, and the Germanic countries, and, upon his return, published his book upon "Institutions for the Insane in Prussia, Austria, and Germany." In 1853 he was elected a visiting physician of the New York City Lunatic Asylum on Blackwell's Island.

In 1855 he returned to Leicester for rest and the confirmation of his health, and passed several years on the homestead of his grandfather, Robert Earle, near Mulberry Grove (now called "Earle Ridge"). During this time, however, he spent the winters of 1862–63 and 1863–64 in the care of the insane soldiers of the army and navy, at the Government Hospital for the Insane, near Washington, D. C., of which his former pupil, Dr. Charles H. Nichols, was superintendent. He also wrote for the medical periodicals, and acted as an expert in the trials of several important cases involving the question of insanity before the legal tribunals of Massachusetts and the adjoining States.

Without seeking the position, he was appointed superintendent of the State Lunatic Hospital at Northampton, Mass., July 2, 1864, and held the office twenty-one years and three months, resigning it October 1, 1885. He made that hospital in many respects a model institution for the insane; and its trustees, in the resolutions passed at the time of their acceptance of his resignation, expressed as follows not only their own conviction, but the general judgment with reference to the value of his administration: "In its management he has combined the highest professional skill and acquirement with rare executive ability. By his patient attention to details, by his wisdom and firmness, his absolute fidelity to duty and devotion to the interests of the hospital he has rendered invaluable service to the institution, and to the community which it serves."

They then also expressed the hope that "he will continue to make his home in the institution, that they may continue to profit by his counsels," and they provided that his rooms should always be open and ready for his use. This offer Dr. Earle accepted, although his summers were spent at Mulberry Grove.

The Northampton Hospital had been erected in opposition to a widely prevalent opinion that it was not and never could be needed—an opinion which delayed its construction, made the obtaining of appropriations very difficult, and finally compelled the trustees to put it in operation in a very incomplete condition, internally. The civil war had tended to restrict the price of board for public patients to a very low limit, and in 1864, when Dr. Earle took charge of it, it had never paid its current expenses. He immediately addressed himself to the task of making it not only a first-class curative institution, but a self-supporting one as well. He purchased supplies at wholesale and in open market. He reorganized and reduced to a very complete system all the departments—domestic, economical, financial, and medical—with checks and counterchecks for the detection of loss, or of waste by carelessness, as well as for the exposure of unfaithfulness in the discharge of duty toward the patients, or in other respects. The so-called "moral treatment" of the patients was amplified, made more diversified, and extended over a greater portion of the year than in any other American hospital.

The pecuniary results of this system were the payment of current expenses in the second year, and during the whole period of Dr. Earle's service, the purchase of land at a cost of over twenty-five thousand dollars; the payment for all ordinary repairs, and over one hundred and seventy-three thousand dollars for buildings and other improvements, and an increase in cash assets and provisions and supplies of over forty-three thousand dollars, all of which became, of course, the property of the State, without any assistance from the State. The results, as productive of an improved curative institution, being less tangible, cannot well be illustrated, but as reflected in current public opinion, they were equally successful.

The importance of occupation for the insane was early recognized by Dr. Earle, and it has nowhere in New England been practically applied to a greater extent than at Northampton. As early as 1870 it was estimated that not less than two-thirds of the manual labor necessary to the running of the hospital was performed by patients.

Believing that a large part of the excessive cost of such hospitals as that at Danvers adds nothing to the curative capability of the institutions, Dr. Earle condemned such expenditure as unwise political economy, ostentatious charity and gross injustice to the payer of taxes.

Dr. Earle has been instrumental in introducing important changes in the treatment of the insane. In 1845 he established a school for the patients in the men's department of the Bloomingdale Asylum, and this was continued for two years. As early as 1840, while in the Frankford Asylum, he gave illustrated lectures on physics to the inmates. "This was the first known attempt to address an audience of the insane in any discourse other than a sermon, and has led to that system of entertainments for the patients now considered indispensable in a first-class hospital." At Northampton he gave a great variety of lectures upon miscellaneous subjects. One course of six lectures was upon diseases of the brain which are accompanied with mental disorder.

The average number of patients who attended them was two hundred and fifty-six. "This is the first time," he says in his annual report, "that an audience of insane persons ever listened to a discourse on their own malady." His observation of the effect on the audience was not unlike that of other preachers. If the listeners were slow to take the application to themselves, they were quite ready to appropriate it "to their neighbors." He also secured lectures and entertainments from other sources, and provided amusements in which the inmates participated.

PLINY EARLE.

Dr. Earle is the author of many papers upon insanity and other subjects, which have been published in the *Journal of Insanity*, the *American Journal of the Medical Sciences*, etc. Some of these have been issued in pamphlet form. He anticipated by many years the valuable treatise of Dr. B. Jay Jeffries, in a paper on "The Inability to Distinguish Colors." His twenty-two reports of the Northampton Hospital are classics in the literature of mental disease. By a combination of causes the public, so far as they knew or cared about the subject, had come to the belief that from seventy-five to ninety per cent. of the insane can be cured at the hospital.

Dr. Earle became convinced of the erroneousness of this belief, and was the first hospital superintendent who combated it. His researches upon the subject extended over a series of years, were embodied in his annual reports, and at length, in 1887, collected and published by the J. B. Lippincott Co., in a book entitled "The Curability of Insanity."

The doctor showed that one cause of the false opinion in regard to curability was the reporting of repeated recoveries of the same person, in paroxysmal insanity. One patient was reported cured six times in one year, another seven times, a third sixteen times in three years, and a fourth forty-six times in the course of her life, and she finally died a raving maniac in one of the hospitals. Judging from the results of the doctor's researches, not one-third of the persons admitted to the Massachusetts insane hospitals have been permanently cured.

Of his work on "The Curability of Insanity," a reviewer writes: "This book may mark an epoch in the literature of insanity, since it has changed the whole front of that literature, and set in motion investigating forces which will carry out its main doctrine into many useful details, upon which the veteran author has not dwelt."

He wrote the article on insanity in the United States census of 1860, and about ninety articles of reviews and bibliographical notices of insane hospital reports and other publications on mental disorders, which appeared in the *American Journal of Medical Sciences* between the years 1841 and 1870.

In a third visit to Europe, in 1871, he visited forty-six institutions for the insane in Ireland, Austria, Italy, and intervening countries. His several foreign tours gave him opportunity to form the acquaintance and enjoy the hospitality of many professional, philanthropic, and literary people; he was well acquainted with Elizabeth Frye, knew the poet Samuel Rogers, and, at their own homes and tables, met socially the Howitts and Charles Dickens. He also cherished pleasant memories of American missionaries in the Levant fifty years ago; of Rev. Jonas King and other missionaries in Athens; Cephas Pasco, at Patras; Simeon Calhoun and David Temple, of Smyrna; Wm. Goodell, Rev. Mr. Shauffler, and Henry A. Homes, at Constantinople. He received kind attentions from all of them, and the home hospitality of several.

Dr. Earle was one of the original members and founders of the American Medical Association, the Association of Medical Superintendents of American Institutions for the Insane, the New York Academy of Medicine, and the New England Psychological Society, of which last-mentioned association he was the first president. He was also president in the official year 1884–85 of the Association of Superintendents. Besides holding a membership of various medical societies, he was a member of the American Philosophical Society, fellow of the New York College of Physicians and Surgeons, corresponding member of the New York Medico-Legal Society and the Medical Society of Athens, Greece, and honorary member of the British Medico-Psychological Association. In 1853 he delivered an adjunct course of lectures on "Mental Diseases," at the College of Physicians and Surgeons in New York City, and in 1863 he was appointed Professor of Materia Medica and Psychologic Medicine, in the Berkshire Medical Institute, at Pittsfield, Mass.

Insanity had never before been included among the required subjects of instruction in any full professorship at any one of the American medical schools. After the delivery of one course of lectures the doctor resigned his professorship, as he had been called to the superintendency of the Northampton Hospital.

In 1888 he published a large volume on the genealogy of the Earle family, a work of great labor, and a model of its class. From this book many of the dates and material facts of this biography are taken. Dr. Earle, up to his death, held his birthright membership in the Society of Friends.

Dr. Earle's generous and valuable gift to the academy in which he pursued his early studies has been elsewhere noticed. He has never wavered in his attachment to Leicester, and his people claim him as one of her honored sons.

Dr. Earle was often called as an expert in criminal cases. Among them the most important are those of Peck, at Greenfield, Mass.; Eastman & Montgomery, at Northampton, Mass.; Smith, at Springfield; Clark, at New Haven, Conn.; Thurston, at Ithaca, N. Y.; Klein & Russ, in New York City; and Charles J. Guiteau, at Washington, D. C. In the case last mentioned, after an attendance of a week he was obliged, by illness, to withdraw.

"Of trials before the tribunals of civil law in which he has been thus engaged, the most widely known are the Parrish will case and the suit for setting aside the marriage of Mary H. Croes, alias Patterson, both in New York City."

The will case was probably the most important trial of the kind ever adjudicated by an American court.

THE CEREBRO-SPINAL AXIS AS A THERMAL CENTER AND WATER POWER.*

By BENJAMIN WARD RICHARDSON, M.D., F.R.S.

MR. PRESIDENT AND GENTLEMEN:

While I feel very much honored by the presence here to-day of the members of the Medico-Psychological Association of Great Britain and Ireland to listen to a theory from me on the cerebro-spinal system as a thermal center and water power, I am, I confess, not a little anxious respecting the result of my labor. I know I stand before a body of listeners who, from their daily avocation as well as from their accomplished training in mental and physical science, form naturally the most critical audience I could address on the subject to be discussed, and this alone is a cause of grave concern. But there is something more before me. I am about to bring forward an entirely new line of research and observation in so elementary a stage that the simplicity of the thesis itself may, at first sight, seem to imperil its acceptance. I must, therefore, with special emphasis, claim, at the onset, your kindest indulgence.

Profound researches have been made into the anatomy of the cerebro-spinal system, into its microscopical structure, into its chemistry. Endless experiments have been performed in order to discover the functions of its different parts; but I am aware of nothing that has been done toward the study of it as a working mechanism, as a fixed central physical instrument playing its part methodically, according to the physical conditions in which it is placed, apart from the more refined details of function which its delicate and minute structures adapt it to perform in many and marvelous ways.

Preliminary Note.

Before I come to the new work on which I wish particularly to speak to-day, it is necessary to refer to the lines of thought and experiment that have led up to the present labor. Experiment making is a very slow and suggestive process. One new observation often unexpectedly opens up another. Constantly the route toward a certain end which, at first, looks clear enough is found to terminate in a *cul de sac*. Constantly it is necessary to go back altogether. Occasionally a new and promising path is disclosed, and all ends well. I hope, almost against hope, it is so now.

ELECTRICAL RESEARCHES.

Early in my physiological career I sedulously inquired, by experiment, whether the nervous centers

* Lecture delivered to the members of the Medico-Psychological Association, at a meeting of the association held at 25 Manchester Square, on Thursday, November 19, 1891, E. B. Whitcombe, Esq., President, in the chair.

could be charged with electrical energy. I tried to construct out of the animal structures a Leyden jar, and to discharge it in regulated directions by conductors. Some curious experiments were arrived at in this inquiry, by which I learned, after a certain fashion, to charge and discharge from the dead brain. But here came the practical difficulty that to do this some foreign structure had to be introduced into the experiment. To explain more precisely, I could not find any structure or tissue of the body that would serve effectively as an insulating medium. All parts were conductors to some extent.

In these labors I had the invaluable aid and advice of the late Mr. Becker, one of the best mechanical electricians of his day; and he agreed with me that in the animal organism there is no insulation. He constructed for me a battery and resistance measurer, by which I carried on some experiments of dynamic order, but the results were uncertain and unsatisfactory.

THEORY OF A NERVOUS ETHER.

In the end, I came to the conclusion that some other more definite principle must be sought after than what is now called electrical energy in the nervous centers, and it then entered into my mind that there might exist in the nervous matter a refined ethereal body, to which I gave the hypothetical name of *nervous ether*. I devoted many months to the study of this subject, and published the description of my views in the *Medical Times and Gazette* for May 6, 1871. The idea here suggested had much on its side, and many persons of mark looked upon it with favor. It was hypothetical, and yet it had many strong points. I supposed that the assumed gaseous or vaporous substance called ether was a chemical product of low boiling point, diffused through the water of the nervous matter; that at the temperature of the blood it was at considerable tension; that it was easily condensible by cold; that it was soluble in water; that in its gaseous or vaporous state it was a medium by which all vibrations were received and conveyed by the organs of sense from without to the brain; and that the collapse of death was due to the cessation of its production, its condensation and inertia. The field of inquiry in the study of this hypothesis was one of the most laborious I ever trod, and was only relieved of its weariness by the fascination of the pursuit. I tried the absorbing power of the brain for every light chemical body that was likely to answer the probable requirements of a nervous ether. As a result I obtained some curious and useful facts, but I failed in the end to satisfy myself of the existence in the brain of an ethereal substance that would serve the purposes named.

RESEARCHES WITH EXTREME COLD GENERALLY AND LOCALLY APPLIED.

The next line of research was of a different stamp, more practical, and yet broadly suggestive. I made a practical study, as you know, of the common ethers for the production of local anæsthesia by extreme cold. At first this study was applied to the effects of cold on the outer surfaces of the body, and to the sensitive terminations or peripheries of nerves. Here it succeeded well, and I began to extend the study to central nervous matter with remarkable and unexpected results. By subjecting the cerebral mass to such a degree of cold that it underwent congelation, all the voluntary functions of the body were suspended. Precisely as in hybernation, an animal whose cerebral centers were subjected to cold lay in deep sleep, the respiration and the circulation proceeding as before, and sustaining the life. If the process of chilling the cerebral substance were rapidly produced the spinal cord was rendered irritable, and unconscious muscular movements were for a time produced; but if the process were conducted while the rest of the body was exposed, at the same time, to moderate cold, so that the break of function between the brain, medulla, and cord was not too abrupt, the torpor was unattended by extra movement of muscles. In the torpor all communications between the external world and the animal were cut off. In plain terms, the cerebrum ceased, for the time, to be an absorbing center. The great center of the volition, cold and consolidated, would not receive light, would not receive sound, would not respond to pungent vapors. It was in the same dead condition as my own skin frozen at a limited point; it would not receive the impression made through a nerve; it was dead to common sensibility, not to mention pain; it ceased to be able to accept or reflect any vibration whatsoever. The water in its substance was waveless, and, for the moment, dead.

It was remarkable to observe that, although the resistance to absorption of vibrations was so complete that actual death could not have intensified it, there was, if the process were skillfully carried out, no death. The vital acts of circulation and respiration were still in progress, and if the nervous structure were allowed to return to its natural state in so gradual a manner as not to cause abrupt change of structure and injury, the recovery from the dead state was a sure and harmless as well as a painless restoration. In the case of warm-blooded animals, like birds, the artificial hybernation could be maintained for many hours with complete recovery if the temperature were allowed to return, slowly, to the natural state. In the case of cold-blooded animals, frogs, toads, and fish, the brain and spinal cord could be brought to inertia, and held in that condition for much longer periods. In my Croonian lecture to the Royal Society on *Muscular Irritability after Systemic Death*, I showed batrachians inclosed in ice, and exhibited their recovery to perfect life from that extreme condition. In another lecture I exhibited some carp that had been accidentally frozen in the Zoological Gardens during a hard frost. They were frozen so completely through that they were practically dead, but I was able to thaw them so gradually and uniformly that as they relaxed from their rigidity they recommenced to live, and showed, after a short time, no evidence of injury from the temporary death in which they had been held. In these animals the whole of the nervous centers, excepting, perhaps, those immediately connected with the heart, had been brought into inertia by the cold.

Researches with Cold Locally Applied.

The above was the effect of extreme cold extended to the whole of the vital nervous matter; but another equally singular fact was discovered, namely, that the same effect of cold could be localized, so that parts only of the cerebral or spinal centers could be suspended in function, while other parts were unaffected. Thus when in birds the corpora striata were made to sleep by cold, the cerebellum being left unaffected, excited volition pushed the body forward, while, if the cerebellum were rendered insensitive, the body was carried backward usually with a series of somersaults. These events had their analogies in injuries and diseased conditions of brain in man himself, as in the temporary paralysis of the anterior centers of the brain on looking over a precipice; as in a case where a patient suffering from disease of the corpora striata was impelled to rush forward, careless as to any obstacle or danger that might stand in his way; and as in some conditions of somnambulism, where the impulse to move forward, regardless of consequences, is the dominant impulse; but I dwell now only on the fact that a portion of the brain structure could, it was found, be artificially brought into hybernation by temporary subjection of the affected part to cold, and that recovery would take place by restoration of the natural condition of fluidity. It was not a little astonishing to find how sharp is the line of demarkation between an affected and an unaffected portion of the cerebral matter. In warm-blooded animals the cerebrum, the cerebellum, part of the medulla, and parts of the cord could be rendered hybernate, and be kept so without danger to life, if the respiratory center of the medulla were left free. In cold bloods the whole could be affected without destruction of vitality.

Cold under Freezing Point.

It was ascertained by further experimental inquiry that, in order to produce very decisive effects, it was not necessary to carry the cold to the extent of actual freezing of the nervous matter. When cold was applied to a vascular part like the skin there were brought to view three stages of action: (*a*) a stage of exaltation of action in which the part was injected with blood; (*b*) a stage of inertia and insensibility in which the structure was left bloodless, firm, and insensible; (*c*) a stage during recovery, the cold being withdrawn, in which there was return of vascularity with that temporary exaltation called, usually, reaction. In a modified way the same thing occurred when the cerebrum was subjected to cold. The pia mater was at first injected, but its surface is so delicate, it soon was emptied of its blood, and the cerebral substance underneath it was rendered inactive without any extreme reactive condition. For this reason it was found comparatively easy to induce temporary somnolency and sleep by a process of moderate abstraction of heat. In one experiment I determined that drowsiness ending in sleep began when the temperature was merely reduced 6° Fah. in the nervous mass, and it was this observation that led me to suggest the original theory that ordinary sleep might well be accounted for as due to nothing more than a molecular change of structure in the nervous organization owing to the dissipation of energy from the brain and its subordinate parts during long periods of labor.

Physical Modification of Parts under Cold.

In yet another series of researches on nervous matter, both in its dead and in its living forms, I found that under the inertia induced by cold the passage of electrical currents through it was resisted. I made the muscles in this case play the part of the galvanometer. On an animal anæsthetized with chloroform, in the year 1867, the sciatic nerve was exposed, and without dividing it a galvanic current was passed through the exposed portion in the direction of its length. The current was now increased until it caused motion in the muscles supplied by the nerve, attended with a deflection of 40° in the galvanometer then used when the current was closed or broken. The nerve was next chilled by the application of ether spray until it was frozen, whereupon the needle fell back to zero, and the muscular motion failed to be excited. Afterward the observation was varied by freezing the nerve, not between the two points included in the line of the nerve, but at a point above, on the brain side. The muscular motion produced by making and breaking contact was now as completely checked as when the frozen part itself was in the circuit. The facts showed that by changing the molecular condition of nervous structure by cold the same interruption to the course of vibration occurs as when the nervous structure is either firmly compressed or actually divided, but with this essential difference, that the cold produced no more than a temporary suspension of function or sleep, easily recovered from; while the mechanical effects of compression or division were apt to terminate in permanent disability. From still further observation in the same direction, it was found that involuntary muscles, like the diaphragm, could have their work suspended by reduction of the temperature of their supplying nerve in its course toward the center from which it arises, as well as from the interruption at that center itself; but that the inertia was most decisive the nearer the interruption was to the muscle, as if the nerve were, in fact, a mere continuation of the center, and in a minor way were still acting when the center itself was out of action.

From these experiments I was led to see that electrical vibration was an excellent test of the working condition of nervous matter, but in applying it there was always this obstacle: that in using the continuous current decompositions were apt to be set up which falsified results. Here, therefore, I was stopped for a long time. At last, in 1879, I was so fortunate as to become possessed of my friend Professor Hughes' beautiful electric balance as a means of research. Now I had an instrument which measured for me from the secondary coil, and by which I could measure through a scale of two hundred degrees of sound, and establish comparisons from minute variations or conditions of the nervous substance under investigation. I put dead nervous matter, brain or cord, after it had been warmed to its natural temperature in a specially constructed chamber, into the circuit, and noted on the scale the degree of conducting power that was exhibited. I raised the temperature of the structure and tested again; I cooled the structure down to freezing point, testing all the way along at stages of different degrees the conducting power. In the end I obtained results which indicated that the conduction became modified according to variations of temperature, increasing with rise of temperature and decreasing with fall in steady and distinctive degree. Also, I brought the structures back from the extreme of cold to natural heat and to fever heat with the reverse results, from all which I inferred, I think justly, that no molecular injury was done to them, but that they had passed through the same physical change as the nervous matter of frozen animals in whom there is returnable vitality from what appears to be the absolute inertia of death. The value of the electrical test in this respect could not be overrated; it seemed to me to differentiate between the condition of death and the condition of life as illustrated by the effects of vibrations on animal matter.

INFERENCES LEADING TO NEW OBSERVATION.

From the study of phenomena of research above quoted, I was naturally led to think of the cause of them. It was easy enough to jump at the conclusion that a frozen brain would cease to be an active brain, that a frozen nerve would cease to be an active nerve; it was easy enough after freezing the peripheral surface of nerve, as on the surface of the skin, to say sensibility is destroyed in the part frozen. But this was not satisfactory: it did not explain what the changes effected; it did not account for local manifestations of the particular kind recorded; and it did not explain what parts in the affected nervous structure were modified in character under the process. Here, therefore, I began to inquire anew.

Giving up, for the time, the theory of a nervous ether, I looked at the construction of the nervous substance from a simple mechanical-physical point of view. In the crude form of it there were the three distinct kinds of matter, namely—water, uncoagulated albumen, phosphorized fat. These parts have their own specific attributes under the influence of heat and cold. The water would not go into solidity under cold until freezing point, and then suddenly with expansion. The fat, however, would pass evenly and by degrees from the fluid into the solid state under cold, and back again by degrees into the fluid state under the influence of heat. The albumen in which the vital endowments would be centered would remain at the normal temperature of the animal body, always fluid, and as free from coagulation as it is in the serum of the blood; it would be diffused through the water of the nervous substance as it is diffused through the serum; and of itself it would not be likely to be affected either by the cold or the heat at blood temperature. At the same time it would play an intermediate part as between the water and the fatty substance; it would cause, as in an emulsion, the fat and the water to unite so as to form a homogeneous compound. If, therefore, cold were applied to this mixture, the inference would be that the whole would undergo gradual cooling, and that the necessary effect of the cooling would be to increase solidification step by step without subjecting the water to congelation. The thought threw new light on construction for function. It suggested to me an explanation of the local action of cold. An expanse or surface of water alone would not show physical change of structure until freezing point was reached, and then a considerable surface would solidify from one point. But what would happen if a surface of a compound of fat, albumen, and water were exposed to cold? The experiment was made, and a comparison was struck. A compound as named was exposed to cold, and was found to solidify long before freezing point was approached. Then brain substance, triturated into solution and freed of membranous substance, was tested in the same manner. It responded in a similar way.

Another observation was made. When cooling of the surface of the compound was localized, the solidification was also local, a fact which corresponded with what had already been observed in the brain in its vital state.

To sum up. The position to which I was led ran as follows. The nervous substance is physically constructed of three parts: *water, soluble albumen, phosphorized fat.* The water, which in a certain manner is solidified, is susceptible of more complete solidification by cold, with the capability of restoration by warmth. The albumen, soluble in the water, and capable, like all similar colloids of hydration, to any degree, moves with the water in respect to solubility. The fat, rendered soluble with the water and albumen, solidifies under cold more readily than water, and becomes fluid by heat more readily, carrying the water with it in its change of physical quality, by which means the nervous substance under limited range of temperature varies in the consistency of its matter.

THEORY OF WATER POWER AND TENSION.

And now I come to the later development of reasoning from and on research, to which I desire particularly to draw attention. One day it struck me that the action of the refined nervous ether, about which I had worried myself so much, might all be effected by water changing in tension, expanding under elevation of temperature by oxidation, into vapor, and condensing under reduction of temperature. If this were so, then much indeed would be explained. Then we might be led to look upon the brain and its subordinate parts as an independent thermal center and water power, acting, however complicate their minute anatomy, as water influenced by the mode of motion called heat.

When the thought was opened there was an immense deal to be said in favor of it. A large part of the nervous matter is water. The degree of physical condensation of water in the closed cavity of the skull is most remarkable. Itself resistant to mechanical compression, it is here, in the simplest way, compressed: compressed into a certain solidity without being frozen, and connected with tubular nerves along which it ought to be able to maintain an extending column of nervous fluid into the remotest parts under the mere impulse of central vibration. If this were so, all impulses would be steadily flowing from the brain into the body during times of cerebral and spinal activity, while all vibrations from the external universe would vibrate back, and unless overwhelming in intensity, would sustain vigorous or subdued action according to temperature, as water in a steam engine in varied tension fashions the motion of the engine.

It was very encouraging to read by the light of theory

so much possible natural fact in support of it. It was as if one ignorant of the action of the watch had suddenly found the mainspring, and had felt one's self able from that instant to understand the movement of the hands and the regulation of their courses. Looking now at the central nervous system as a water power inclosed in resistant bounds, so as to be able to exert action under oxidation and the resultant heat, it lay before me as the mainspring of the animal body to which the blood and circulation play an important but, really, subordinate part. To test this view, I passed again to experimental observation, thinking now of water as a motor under various degrees of tension.

I said to myself, if water vapor be the motor under expansion and condensation, it must, after it has served its purpose, be condensed, and this led me to recall an observation which I originally made on the mode of exit of the cerebro-spinal fluid. I found, as detailed in the first number of the *Asclepiad* in 1884, that the escape of that fluid was by the lower extremity of the spinal cavity into the blood by the inferior cava. From this a fact of supreme importance was discerned. It showed the precaution taken by nature to keep every part of the brain and spinal cord in a water condenser, and the interior of the brain in communion by it with the exterior. The cerebro-spinal fluid is the condensed fluid, and is the regulator of the pressure under the varying moods of oxidation incident to variation of vibration.

When the brain and cord are unusually active, when they are receiving vibrations on every side; when, that is to say, the water tension of the centers is at its height, then the amount of condensated cerebro-spinal fluid poured into the veins must be enormous, and may easily and reasonably account for that free action of the kidneys which in hysteria and other kinds of mental excitement is so constantly observed. When, on the other hand, the central tension is reduced, the accumulation of the water in the ventricles and in the arachnoid sac will fill up the void, and by the even pressure it exerts favor quietude and sleep.

I considered this to be one of the best evidences of the truth of the theory of the brain as a water power. If the cerebro-spinal fluid should accumulate in excess there would follow, as I have more than once shown, deep stupor, coma. If it were drawn off in excess, there would be violent mania. The part played by the fluid is, in fact, in the most refined degree regulatory, and is one of the most beautiful and important parts of the cerebro-spinal mechanism. It is the dialyzed efferent fluid of the nervous centers; it is the condensed fluid of the nervous centers; but, in ebb and flow, according to the tension of those centers, it maintains also equality of balance, and almost certainly governs sleep and wakefulness.

This seemed very natural, and made the theory still more clear as a working theory; but I felt that certain other evidences were wanted, which experiment ought to yield, if the theory were correct. Two views occurred to me in this direction:

(1) I reasoned that if water plays the part supposed, then removal of it from nervous tissue ought to have the same effects in regard to vibration as condensing it by cold. That is to say, removal of water ought to reduce conduction in proportion to removal, while removal of fat ought to increase it.

(2) If the theory were true, there must be in the cerebro-spinal axis a steady combustion or oxidation, that stands alone, that is, in a sense, independent, a sovereignty that works the central power by its own mere motion. It also must be a modified as well as steady combustion, and the products of it must be soluble and dialyzable. We ought, therefore, to be able to excite a combustion in nervous matter, even when it is dead.

In order to test the first of these propositions, I followed the same series of inquiries, in regard to electrical vibration after the mere removal of water, as I did when the nervous matter was condensed by cold. Brain, spinal cord, and sections of nerves were subjected to observation under various degrees of hydration. A portion of the substance to be tested was placed in the electric balance, and its conducting power carefully noted. While charged with its water it was placed, at 100° F., in the drying chamber in order to be dried down to complete dryness, and as the process went on the conduction was tested day by day. The conduction was found to decline in proportion as the water disappeared, until, on complete desiccation, conduction ceased altogether. No demonstration can be clearer. It can be carried, so to say, backward and forward. The nervous matter can be dried down to complete inertia, and by exposure to water vapor, which it will readily reabsorb, can be made to resume its full conducting power. The fact explains why in some animals exposed to slow evaporation the nervous system may be brought to such inertia that death itself seems absolute; and yet, on immersing the animals in water, they revive and relive. This is the equivalent to hybernation from the action of cold.

I made an inquiry relating to removal of fatty matter. It was seen that, under cold, the presence of fat in nervous matter modified the action of cold, so that condensation progressed sufficiently to interrupt function before freezing occurred. The fact led me to ask what would be the effect of removing the fat and letting the water remain. The experiment was tested. Portions of nervous matter, brain and cord, were taken in the fresh state from the sheep just killed, and conduction was tested. The sections were placed in ether or in bisulphide of carbon and left until the fatty matter was dissolved out; then, being removed, the test was reapplied, with the result of finding that the conducting power had increased, by removal of the fat, ten degrees. Sections were tested also in intermediate stages with proportionate increase of conduction, according to the removal of fatty substance.

Hitherto I had made electric vibration the test of activity. I moved to the vibration of sound, and here again the telephone and balance came to my assistance. By putting nervous material between the vibratory drum of the telephone and the ear, I was enabled to detect variations under many varying conditions of the nervous material. The results were most important. There is not time to refer to them here in detail, and they are too delicate to be made matter of illustration so that all present could verify them at once; but, briefly, they showed that absorption of sound by the nervous matter was most perfect when the water was in full, but not extreme, tension, that removal of tension by condensation lessened absorption, and that high tension increased it.

Turning to the second proposition for inquiry, namely, the combustion that is present in the nervous centers, I was helped considerably by a significant fact which I had learned in my earlier experiments on heat and cold. I had found by direct observation that, whatever was the nature of the combustion going on in the nervous centers, it was attended, in all animals, even in birds—in whose bodies what would be the highest fever heat in men is the natural condition—with a much lower development of temperature than in other active organs of the body. A difference of 4° F. was observed between the brain and the liver and 2° between the brain and the arterial blood. Moreover, I had learned in the most singular manner that there is going on in the living brain an actual phosphorescent combustion from oxidation, a combustion that would yield a steady low temperature with soluble products that would easily dialyze and make their way out of the nervous substance both by the blood and by the cerebro-spinal fluid. Whether combustion of carbon takes place in the substance of the brain or cord, with liberation of a gaseous product like carbonic anhydride, remains to be determined; but the oxidation of phosphorus there, with production of dialyzable products, cannot be doubted. It was necessary, therefore, to take this modified oxidation into account, with the surmise that the lower temperature of the brain in its natural state, compared with that of other vascular organs, is from this cause. On this inquiry I have been long, and am still, engaged.

I have carried out the inquiry by taking the dead brain of the sheep divested of its membranes, and rubbing it into pulp or emulsion. The emulsion is phosphorized by the simple process of mixing with it phosphorus dissolved in carbon bisulphide; the bisulphide is rapidly removed by the air pump, leaving the phosphorus in the finest state of distribution in the emulsion. The phosphorized brain mass is now experimented on in divers ways. A mould of albumenized tissue involuted into convolutions is charged with the brain substance, and is then floated on richly oxidized blood—derived from the same slaughtered animal—rendered alkaline with soda, and placed at the temperature natural to that blood. The oxidation is sustained for several hours, the blood being often removed and changed for new blood freshly oxidized. Under the warmth the brain pulp oxidizes, until a slow combustion is established through the whole structure. It yields, during condensation, a fluid analogous to the cerebro-spinal, a gray exterior, where the blood has dipped, and a white central interior mass.

Into these experiments I introduced another line of research. I mixed with the oxidized blood different foreign substances, in order to see if they were accounted for after the exposure to the combustion. Some, like alcohol, were rapidly changed, others, like strychnine, slowly.

I would like to dwell on these experiments and on others similar, but my time is nearly exhausted, and I have yet to glance at the bearings of the theory I have advanced on some of those diseases with which you are most familiar. As preparatory to such application let me, however, in a brief summary place before you the argument of the theory under a few distinct heads.

The Argument.

(1) The cerebro-spinal axis is a static thermal center and a water power—the mainspring of all vital actions. The cerebro-spinal nerves are tubular continuations of the white matter of the centers, producing a fluid responsive to the centers themselves, practically static, and liquid during life, but susceptible, while normal, of receiving and conveying pressures, much in the same manner as the fluid in a barometric tube; susceptible also of rapid condensation on change of condition from the natural state.

(2) In those parts of the centers called gray, where the surface comes in contact with blood charged with oxygen, there is in progress a slow combustion in which phosphorus plays a leading part, maintaining an equably reduced combustion, with the formation of dialyzable saline products. The gray matter, the seat of the combustion, takes its color from the blood, extending to the depth of the blood membrane, dipping into it from its surface, and separated by the convoluted blood membrane into centers, each center possessing its own surface of oxidation and acting as an independent organ. The white matter, on its part, is the great receptive center, supplying combustion material, to the gray centers of combustion, as the stem of the candle supplies the wick, but acting also as the receptive medium of vibration to and from the vibrating nerves. In the combustion of the great centers sufficient heat is developed to bring the whole volume of the centers into proper tension. In the nervous cords the same process is going on, so that under the combustion sustained by the centers the nervous cords, cerebral and spinal, are brought also into natural tension for conveying vibrations from the centers to the peripheries, and from the peripheries back to the centers. The nervous fluid in the nerves is practically static and easily condensed under exposure or injury; but it is most probable that at their peripheral terminations they give up fluid during central pressure, which fluid stimulates muscles into contraction and glands into excretion.

(3) The theory accounts for the grand nervous phenomena of life in their activity during wakefulness, and their repose in sleep. Wakefulness and sleep depend on variations of tension. When the brain is at full, but not too extreme, tension; when the cerebral fire is at full, but not excessive, work, all parts that respond to it are active and wakeful. When the tension is reduced—in other words, when the oxidation wanes—the process of central condensation comes on, with production of cerebro-spinal fluid and phenomena of weariness and sleep, which last until the cerebral fire attains its restoration, tension is restored, and the organic functions subservient to the nervous, including the muscular functions, are brought back to what is called life. The cerebro-spinal system is, in fact, a true water engine, so true that an artificial engine acting on the same principles could be constructed upon it for the production of motion.

(4) The theory explains the well known effects of varying external pressures and temperatures on the central nervous organism. Atmospheric pressure tells on it through the nervous expanse, as it does, only in a more refined degree, on the mercury or spirit of the barometer. Reduced pressure of moderate degree would give a freer expansion to the centers. High temperature without evaporation would produce enfeebled tension; low temperature, in moderate degree, would favor high tension; but an extremely low tension, sufficient to produce actual solidification of nervous surface, central or circumferential, would produce complete cessation of action, a fact that admits of demonstrable proof, local and general, by the action of cold.

(5) The theory attributes to the cerebro-spinal fluid the most important functions. It declares this fluid to be the condensed fluid of the combustion of the cerebro-spinal axis, the regulator of pressure, and the medium by which many poisonous substances are removed from the blood. Charged and recharged with various foreign substances like alcohol, glucose, urea, chloral, strychnine, it eliminates some directly, others, less decomposable, by repetitions of eliminations marked by paroxysmal seizures.

(6) The cerebro-spinal axis is not merely an absorbing center for the reception of external vibrations, but a true chemical and dialyzing center, and the center of the static combustion, by which under the fluid pressure, regulated by the spinal fluid, the nervous tension is sustained in all parts of the body having nervous communications with it. It is a true physical autonomy.

(7) Under this theory, ganglia are supplementary centers, supplied from the main source. They lie as intermediates between the great centers and the involuntary muscles, feeding the involuntary muscles with nervous stimulus in steady and continuous supply so long as they are steadily supplied themselves, but exciting the muscles, when oversupplied, to overaction. Plexuses, in their turn, are intercommunicating points or meetings of nerves in order to enable vibrations to be carried on should one or more nerves belonging to a plexus fail in function from disease or injury. Decussating fibers are explained as the means by which centers are prevented from becoming independent of each other and losing compensating balance.

(8) If the theory be correct, two distinct combustions exist in the animal body, one the central or nervous combustion, a combustion leading to low tension and pressure, the static combustion; the other that higher combustion of the muscular and active vital organs, the combustion yielding the animal heat which we recognize as the sensible heat of the body, having its own independent and, apparently, more active function; and yet, possibly, dependent for its continuous existence on the slower and central combustion which keeps it alight, and regulates its activity by regulating its supply of blood and, therewith, its oxygen and its combustible material.

PRACTICAL APPLICATIONS OF THE THEORY TO SOME FORMS OF CEREBRO-SPINAL DISEASE.

Under this theory an immense number of explanations of phenomena hitherto unexplained come, I hope, into view with perspicuity. Whatever should quicken or exalt the nervous combustion at the center should quicken the current of impulse along the nervous tracts and excite muscular motion from action to overaction. Whatever should reduce the central oxidation should reduce the nervous currents, and produce sleep, or in extreme degree collapse and inertia, or death. Let there be removed, rapidly, the supply of oxygen carried by the blood, let the brain fire, that is to say, be suddenly put out, as in hemorrhage, and so rapid will be the condensation that for a brief interval, under the pressure, the nervous influx into the muscles will throw them into convulsion and rigidity. Let the brain temperature be raised as in fever, and straightway there must be an excessive nervous excitement, an overflow of nervous current, with quickened action of the involuntary muscular pulsations and direct radiation of the increased heat from the cutaneous surface of the body, the mucous surface of the viscera, and the serous expanses. What is called a chill from exposure of the body to cold or wet is explainable on this theory. The peripheral nervous surface, arrested in radiation, receives a check primarily, followed by a necessary excess of temperature and that fever which always follows sudden arrest of peripheral function.

The phenomena of inflammation, local and general, are also explainable on the theory without any complication or difficulty; but what I would now notice more particularly is the exposition it offers in relation to some forms of cerebral disease.

Reflex Action—Epilepsy.

The phenomenon of reflex nervous action is by it rendered explicable. The impression on the peripheral surface, which gives rise to the reflex movement, after vibrating along the aqueous line up to the center, radiates out at the center, and exciting quicker oxidation there, causes an impulse which produces local central injury with return vibration back by the nerves to be dissipated in the muscle or muscles which the conducting nerves supply. But for this time is required, and therefore the time of the reflex. If the impression be too severe and too universal, there may be no reflex, but an actual injury to the nervous center, a stun, a stroke, or an apoplexy, fatal possibly, or if not followed by a reactive flash of vibrations from the center to great groups of muscles, causing general convulsion. Epileptic seizures, on this argument, may be peripheral in origin, due to an intense vibration sent to the grand centers, temporary increase of vibration there, and radiation back into the muscles until, by exhaustion of the excitement by the muscles, equilibrium is restored. In other words, if there were no epilepsy, there would be apoplexy and death; so that the very phenomena of the seizure are indications of the mode by which its occurrence and repetition are compatible with continuance of life.

Mania.

By this same theory acute mania is logically explainable as a fever; an overaction of the great nervous centers, springing up originally either in them,

or from quickened oxidation developed in some part of the nervous expanse, in periphery, as in acute pneumonia or pleurisy.

Mania may also be accounted for from changes in the cerebro-spinal fluid. If the cerebro-spinal fluid were rapidly drawn off, the inevitable result must be convulsive movement and spasmodic movement, with intense excitement, up to tetanus. If it were drawn off slowly with other fluid from the blood, the result would be collapse, with spasms, as in cholera. If it accumulate in quantity, the result would be coma from pressure, with convulsive movements. If it collect into itself toxic substances, the result will vary according to the substances.

Structural Changes.

The theory applies to the explanation of structural changes in the nervous masses themselves. Excess of fatty matter in them must reduce the oxidation. Increase of water in the subtance must also lessen oxidation, induce pressure, lead to general absence of tension, and cause paralysis. Alcohol in the centers must lead to quick and temporary expansion and excitement, probably from combustion of it there, followed by extreme condensation, stupor, and exhaustion. Many times repeated the action of alcohol in producing general palsy is a necessity in those who are unable to eliminate the substance with rapidity.

Toxic Substances.

One more word. I found in experiments on cerebral oxidation that the process was very much impeded by the presence of some foreign substance. If, for instance, the carbon bisulphide were not well removed, the oxidation was checked. It has been observed that workers exposed long to the vapors of carbon bisulphide become affected with a special paralysis and cerebral failure, and now we see that this phenomenon is, under the circumstances, inevitable. I name this because similar interruptions to cerebral oxidation may be induced by other disturbing substances, and melancholia and hypochondriasis may be traceable, ultimately, to some persistent disturbance of this nature.

By this theory the phenomenon of alcoholic craving is naturally accounted for. If alcohol is burned in the brain fire and feeds it, the crave for alcohol may well be as insatiable as we know it to be in the alcohol-stricken.—*From the Asclepiad.*

COLOR HARMONY.*

MR. KELLY.—In order to understand the general scope of color I think it best to commence at the very beginning. I will run over the subject hastily. First the terms generally used by painters are greatly confounded. Tints, hues, shades, neutrals and a number of other words applied to colors are used indiscriminately without positive knowledge of the derivation.

As I run over the charts I have here you will get a short practical illustration of just the different properties or proportions of colors. Beginning with the first chart, we represent the sun. All color is proportions or divisions of sunlight. Any material, as I understand it, affords no such thing known as color, and there is no color in any material. Color is the action of sunlight on material—the property of material reflecting sunlight. Sunlight is composed of three sets of rays—red, yellow, and blue. Material is composed of small particles of, as it were, sand, particles so small that we cannot see them. This "sand" is of different shapes, one kind of shape, for instance, like the ordinary house brick, fitting together tight. Material of this shape reflects all the sun back to our eyes and produces white. If our material is of such a shape as to have openings like a sieve, letting all the sunlight pass through, we call it black. If again of such a shape as to permit yellow and blue rays to pass through and reflect the red, we call it red material. We have these three colors, red, yellow, blue, primary colors. Outside of these we have a row of three other colors called secondary colors, or the second row made by mixing the inside row together. Any two colors of the outside row, called the tertiary, are made by mixing the second row together, which gives us the third row. Although scientifically white and black are not known as colors. The first little square we have is primary; the second, the secondary colors, violet, orange, and green; the third, the tertiary. The tertiary row is russet, citrine, and olive. The last we have is the neutral, black, gray, and white. Gray is any combination of black and white; pure gray is half and half. The first property we have of color is hue. This is color in its purity, like sunlight. The purest colors we have are English vermilion, ultramarine blue, and lemon yellow. We have pure and neutral hues. To form a neutral hue we take a neutral, any proportion of gray, and add it to a hue. The top line represents neutral hues of red. The left hand square is pure hue. The right hand shows a proportion of hues in that strip. The row of squares on the left shows pure hues of long strips and the proportion used to produce these hues. The center strip we have pure hues again. Next to hues we have tints. Tint is any color placed in sunlight where you will get a reflection, or, in other words, in the painter's terms, a tint would be any color with white added. Here we have a pure red gradually adding white, bringing to about one-half white. We have pure tints and neutral tints. A neutral tint is white and black added to a color where the white predominates. At the right hand side of the red we have shades of red. The shade of a color is a color placed in darkness. If I take a red piece of cardboard into a room fifteen or twenty feet back, without windows, and I place the red in the room gradually, it would take the shade and give a dead black, simply showing that shades of red are darkness added. We have pure shades of all colors, then neutral shades. These are equal to neutral tints, excepting that black predominates. We add black and white to produce the neutral shades.

Next we have what is known as harmony of color. This is the same as harmony of music. I refer to this as the general public are generally educated in music, while in color we are quite in the background. We are far behind what science has developed. When we strike two notes on a piano, if they are pleasing to the ear, we say it is a harmony. This is produced by equal vibrations of air. A little hammer strikes a string, causing the string to vibrate in the center and waving the air equally in strength and pulsations and equally in their distance apart. Sunlight is composed of infinitely small waves of light. Ether waves they are called; when they pass from the sun to the earth, they pass in a straight direction. If there is nothing to disturb the motion of those waves, we call it harmony. If we have the red or blue waves crossing each other, we have a discord. This discord shows in colors as spots, as is seen on a smooth plastered ceiling. If frescoed, the color seems to be spotted. So to have color in perfect harmony these other waves must not conflict. We have a contrast in harmony, blending harmony, an individual harmony. First let us consider individual harmony. We have two or more colors placed side by side. Two or more shades of any color is individual harmony. If you wish individual harmony of blue, you take blue and add black or white in any or all proportions to suit. You cannot get any discord. The same is true of the other colors. Take, for instance, those light pinks and add a brown shade to red, and you cannot go wrong. Next, we come to blending harmony. Any two colors put side by side generally produce a new color where they lap. Any two colors in a regular order, as in rainbows, are always in harmony, as violet and indigo. We can put these together and produce no new color. Blue and green to a yellow, yellow to an orange, and orange to a red. Those only can be used in blending which are in perfect discord when used in solid colors.

Contrast in harmony. This is two colors placed side by side, which will improve each other and enhance and beautify each other. We cannot put any two colors together that do not have the same color in their composition. Take, for instance, yellow and blue, they produce green. Any tint or shade of the opposite is always in perfect contrast with green. It is a very simple rule and you cannot get wrong. The red and yellow produce all the tints of the orange. The opposite of orange is a blue.

Tone of color. Tone of color is that property of color which holds heat and which acts on our imagination. Although it is a very slight difference in temperature, it has been found by testing that there is a difference of eighteen degrees in three minutes between a glass filled with blue water and one with red by focusing the sunlight on it. If we are tinting a room to be used in the winter, use red or browns or anything that is composed of red, and it will appear to be a great deal warmer than it really is. If we use yellow, we have a neutral effect. If blue, a cold effect. For blue is cold in tone, yellow is neutral.

I will make a few of the colors to show how the different hues, tints, and shades are made. Any person present can call for any color he would like to have produced. I will say further that all the colors known as opaque colors can be produced with these three—red, yellow, and blue. As they can in dyes, but cannot take an oil color and produce a dye color. First, contrasting harmonies. As I said before, contrasts in color improve each other—do not fade; beginning at the top of the card, you will notice the difference and notice whether it improves or fades, and give your answer. Green is any and all proportions of yellow and blue. Neutral color is black, white and gray. (The lecturer then compared the colors on the plates and asked the audience to give the effects.) Another thing which bothers many painters is what proportion to use on a frieze about a picture moulding, after selecting your harmony to tell how strong or weak is the color. Our eyes, to see naturally, require all the colors in equal parts, red, yellow, and blue, or, in other words, pure white. So then, to have a room look right and proper, we should have the same amount of color in the door casing as in the wall. If we have a strip four inches in width, we have as much color then as material. We must have as much to reflect back sunlight in one as in the other. Suppose we are going to use yellow. (The lecturer here painted an equilateral triangle in lemon yellow, and on the bottom side painted a strip of the darkest color required. He then took a brush and brushed up and down, thus distributing the dark color over the surface of the triangle, making a perfect graduation from the apex of the triangle to the opposite side.) At this point we would have a ceiling color. This ceiling color divides this into four parts, this is the wall color. The ceiling should be twenty-five per cent. lighter to produce the same effect on the side wall. Take the width of your door casings, which are right across the triangle, the width of the casing, and this gives you the color. The narrower the casing the sharper the color. You do not have to use the same color, simply the strength.

(A delegate asked that an exposition of tints be shown.) The tint of any color is white added to any color. (To get this the lecturer pinned upon the wall a

piece of shellacked paper, having an open rectangle. He then painted diagonally across one-half from opposite corners in blue and the other half in white, and then blended it by using a clean brush vertically, giving a perfectly graduated tint from dark blue to white.)

* Abstract from the recent convention of the New Jersey Association of Master Painters and Decorators.—*Painting and Decorating.*

BENZINE IN BLEACHING.

MAHIEU'S process consists in mixing benzine with the solutions of carbonate of soda used in the different bleaching operations, or with the baths of chloride of lime or other bleaching chlorides. This application of benzine in the lyes has the effect of dissolving and removing the vegetable coloring and resinous substances contained in the textile matters. Taking, for instance, 1,000 kil. linen to bleach, the way of operating after this method is as follows, viz.:

In a sheet iron keir or other reservoir containing 200 lit. water, 50 kil. soda (preferably Solvay soda) are heated for fifteen minutes at about 100° C., when 1¼—1½ lit. benzine is added and heating continued for ten minutes, the mixing operation taking up twenty-five minutes in all. After standing for ten minutes the mixture is let out into another keir placed under the first, containing 5,000 lit. hot water and 12½ kil. lime. This lime water bath is prepared one hour in advance and heated to 90—100° C. This new mixture is heated for another hour, and then left to stand for twelve hours before using it. The 1,000 kil. linen being placed in a proper tub, and the prepared lye run in, it is boiled for three hours under 1½ atmospheres pressure, instead of five hours as usual.

This process applies to the whole habitual course of operations, which are more or less often repeated according to the degree of bleaching required, that is:

1. Benzine lye as above indicated.
2. Rinsing in running water.
3. Chloride of lime bath.
4. Rinsing.
5. Neutralization of the chlorine.
6. Rinsing.
7. Grass bleach.

Benzine is also added to the chlorine bath, thus: Mix 8 kil. benzine with 60 kil. Solvay soda, and let it boil up; run this mixture into a cistern containing 4,000 lit. solution of lime 8°, or about 4 per cent. benzine. Then the chlorine baths are prepared, as stated, to the required strength, and the yarns or linens laid down in them for the suitable period.

This process renders all the ordinary bleaching operations more active, at the same time shortening them, maintains the fibers at their original strength, and affords a considerable saving in steam and chemicals.—*Textile Colorist.*

EXPLOSIVE SUBSTANCES.

By CHARLES D. LIPPINCOTT.

THE following paper was, says the *Pharmaceutical Era*, read before the Pennsylvania Pharmaceutical Association at its meeting in 1886.

SECTION FIRST.—*a. Substances which explode when triturated singly.*—Under this head are to be found only a limited number, among which are:

1. Potash chlorate (commercial), under sharp contusion.
2. Mercury fulminate, explodes with green flame.
3. Mercury nitric oxide.
4. Copper nitrate, dry.
5. Copper fulminate.
6. Antimony fulminate.
7. Gold fulminate.
8. Silver fulminate.
9. Glonoin (nitroglycerine).
10. Hydrogen chloride.
11. Nitrogen iodide.
12. Nitrogen chloride.

The latter three substances and the fulminates are among the most violent of the explosives, their chemical stability being very light.

It may be well to state that in substances which contain carbon, oxygen, and nitrogen, the latter in a more or less feeble state of combination with the whole or part of the oxygen, when the explosion takes place the N parts with its O, which combines with the C, forming CO_2 and CO with generation of heat, and N is set free.

If H be present in the explosion, H_2O is formed in the form of greatly expanded vapor. When Cl is present, it takes the part of the N as from potash chlorate.

We find that nitro substitution for H forms very dangerous explosive compounds, as glonoin, a tri nitro product, also xylodine, a bi nitro, and last, but not least, nitro mannite, a product from manna sugar, and containing six molecules of nitric peroxide (N_2O_5) associated with the carbon of the sugar.

b. Substances which explode when mixed with other substances and triturated:

1. Potash chlorate with acid tannic.
2. Potash chlorate with sulphur.
3. Potash chlorate with antimony sulphuret.
4. Potash chlorate with pot. nit. and ammon. phosphate.
5. Potash chlorate with picrate of ammonia.
6. Potash chlorate with am., sulph., copper and soda hyposulphite.
7. Potash chlorate with picrate of potash produces purple flame.
8. Potash chlorate with picric acid, yellow flame.
9. Potash chlorate with acid oxalic, detonates violently.
10. Potash chlorate with potash permanganate, detonates.
11. Potash chlorate with sulphur and iodine, violent detonation.
12. Potash chlorate with antimony sulphuret.
13. Potash chlorate with sulphur and fulminate of mercury (very sensitive).
14. Potash chlorate with potash prussiate and sugar.
15. Potash chlorate with ammonio sulphate of copper.
16. Potash chlorate with soda hyposulphite, fuses and deflagrates.
17. Potash nitrate, dry carbonate of potash and sulphur.
18. Potash permanganate and tannin, deflagrates.
19. Potash permanganate and picric acid, violent detonation.
20. Potash permanganate, picric acid, and tannin, violent detonation, with yellow flame.
21. Potash permanganate and potash picrate (loud).
22. Potash permanganate, potash picrate, and tannin, very loud.
23. Potash permanganate and potash oxalate.
24. Potash permanganate, potash oxalate, and tannin, violent.
25. Chloride of lime and iodine and iodine resub. (detonates).
26. Dry nitrate of copper and oxalate of potassa, with tannin acid, explodes.
27. Antimony sulphuret, acid picric, and potassa chlorate, detonates with flash.
28. Amorphous phosphorus, acid tannic, acid picric, potassa chlorate, potash permanganate (very sensitive, flashes *without detonation*).
29. Manganese black oxide, picric acid, permanganate of potash, flash, no detonation unless confined.
30. Potassa bichromate, tannin, and picric acid (orange red flash).

31. Potassa biehromate, tannin, picric acid, and amorphous phosphorus, red flash.

32. Ammonium picrate, potassa nitrate, powdered charcoal. Nitric acid with this combination one part, ammonium pigrate two parts, and potassa nitrate three parts, forms what is known as *picric powder*.

The following are a few explosive mixtures brought into closer or more compact union by the solvent power of a suitable menstruum; certain component parts, however, remaining in suspension.

33. Indigo, acid tanpic, potash chlorate, and amorphous phosphorus, diluted alcohol q. s. to form paste, when dry, is violently explosive, giving off a volume of white smoke.

34. Soda chlorate with golden sulphuret of antimony, very sensitive, emits crackling sounds.

35. Lamp black, amorphous phosphorus, strontia nitrate, tannic acid, spts. turpentine, to form paste, detonates with red flash and white smoke.

36. Substitute dry ammonia, sulphate of copper or dry cupric oxide, for strontia, a beautiful blue flash with loud report results.

37. Starch or dextrine	10	parts.
Potash chlorate	20	"
Amorphous phosphorus	5	"
Water	8	"

Mix. When dry produces loud detonation, if confined, evolving copious white smoke.

38. Acid sulphuric	75	parts.
Acid nitric	30	"
Simple sirup	20	"

This mixture is known by name of "Vigorite."

39. Another composed of vigorite, nitrate of potash, and cellulose, is known by the name of "Nitroline."

These two compounds are dangerously explosive.

40. Lac sulphur, golden sulphuret of antimony, valerianate of zinc, chlorate of potassa. This combination has been prescribed and has exploded.

41. Iodine fulminates with turpentine and most of the hydrocarbon volatile oils.

Any of the nitrates will form explosive mixture with combustible substances.

The chlorates, however, part with their O more easily than the nitrates, and in consequence of the strong affinity of chlorine for the metals, chlorine mixtures are very sensible to friction and percussion.

In explosive compounds the elements are all in chemical combination; presenting a definite explosive molecule (*i. e.*, containing both combustible and supporter of combustion); hence we can readily understand how an explosive *compound* is more sudden and violent than that of the most intimate mechanical mixture.

Potassium chlorate and all the other chlorates should never be prescribed in powder, mixed with organic and inorganic, combustible, or oxidizable bodies. They should, therefore, when combined, be prescribed only in solution.

The following prescriptions have been known to explode, and are dangerous.

℞ Potassa chlorate.
Sodium or calcium, hypophosphite. ℥j
Aqua. M.

The two salts should be dissolved separately.

℞ Potassa chlorate.
Acid tannic.
Glycerine.
Aqua.

This should be prepared by making a solution of the tannin in the glycerine and potassa chlorate in the water.

℞ Potassa chlorate.
Pulv. catechu. Should not be dispensed.

℞ Potassa chlorate.
Pulv. gallæ or acid tannic.

SECTION SECOND.—*Substances which undergo or are liable to spontaneous combustion.*—Under this head we find that all compounds that contain oxygen and chlorine, feebly combined with carbon, are liable to undergo spontaneous combustion, by the elimination of O or O and Cl, causing the generation of sufficient heat to inflame the C.

The following comprise those which I have found by experiment and research to undergo this change:

1. Silver oxide and creosote.
2. Potassium permanganate and glycerine. (Spontaneously deflagrates.)
3. Potassium permanganate and acid oxalic. Fuses and deflagrates.

The following prescriptions, under this head, are dangerous; all of which have exploded spontaneously; hence should not be handled by empirical manipulators.

4. ℞ Potassa chlorate.
Tr. chlor. iron.
Glycerine. If warm, will explode.

5. ℞ Potassa permanganate.
Alcohol.
Aqua distil.

This may be dispensed by adding the potassa slowly to the alcohol and water previously mixed, and by dispensing in a loosely stoppered vial.

6. ℞ Oil amber.
Acid nitric; explodes with penetrating odor resembling musk.

7. ℞ Oxide of silver.
Muriate of morphia.
Extract of gentian.

8. ℞ Oil turpentine.
Acid sulphuric.

Should be mixed gradually in an open vessel, as this has caused violent explosions and serious accidents.

9. ℞ Acid chromic.
Glycerine.

May be combined by adding the acid by degrees, rubbing slowly.

10. ℞ Iodine.
Spts. camphor.
Camph. soap liniment.

This evolves nitrogen iodide.

11. ℞ Acid nitric.
Acid muriatic.
Tinct. nux vomica. (Explodes in two hours.)

12. ℞ Potassa sulphate.
Aqua rosæ.
Tinct. benzoin.

13. ℞ Soda borate.
Soda bicarb.
Glycerine.
Water.

Evolves CO_2, therefore explodes when corked too tight.

In general those mixtures that give off gas should not be corked until the evolution of gas is over. In evidence of the action of the rapid evolution of O in contact with any combustible substance, especially any volatile or inflammable substance, the following affords a good example:

Take of sulphuric acid one fluid drachm, permanganate of potash fifteen grains. Mix in a small mortar. By dipping a glass rod in this solution and touching it to a small quantity of cotton, previously saturated with alcohol, the latter will immediately take fire.

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